KUMAR

C.R.C.

OBJECTIVE

Botany

A STANDARD BOOK FOR

PMT, CPMT, CBSE, BHU, AMU, AIIMS, AFMC, JEE (Orissa), BCECE, CEE, CET & all other Medical Entrance Exams.

DR. NARESH KUMAR

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Regard :.
M. Umair
CR. MSc Botany
(2017-2019)

PRAKASH PUBLICATIONS
MUZAFFARNAGAR (U.P.)

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- When the runners are with thick internodes, they are called sobole.

(b) Stolon : In some plants the nodes of horizontally growing underground stem give rise to branches which come out of the soil. The lower portion of nodes give rise to roots, *e.g., Fragaria* (strawberry), *Jasminum* (jasmine), *Colocasia*, etc.

(c) Sucker : Suckers are formed from the node of underground stem. Stem and sucker both grow horizontally under the soil but sucker comes up obliquely in the form of leafy shoot. Roots are formed from the lower portion of nodes, *e.g., Mentha* (mint), *Chrysanthemum*, etc.

(d) Offset : Stem consists of thick and short internodes. The branches are formed from the main stem and upper portion of each branch is curved which bears a group of leaves while the lower portion bears the roots. Each branch is capable of growing as an independent plant after separating from the parent plant, *e.g., Eichhornia* (water hyacinth), *Pistia*, etc.

(C) Aerial modifications

In some plants the aerial portion of stem is modified into different forms, to perform different functions, *e.g.,* climbing, protection, food manufacturing, etc.. Some of the aerial modification of stem are:

(a) Tendrils : The stem of some plants cannot keep upright on their own so to climb up, their axillary buds are modified into coiled, wiry, thin structures called tendrils. *e.g., Passiflora* (passion flower), *Vitis* (grapevine), groundnut, etc.

(b) Phylloclade : In some plants instead of leaf, the stem performs the function of photosynthesis. The stem modifies into green fleshy leaf like structure having distinct nodes and internodes. Stem also stores food.

Leaves of such plants are reduced into spines in order to prevent loss of water, *e.g., Opuntia* (prickly pear), *Euphorbia, Ruscus, Muehlenbeckia* (cocoloba), etc.

(c) Cladode : These are somewhat similar to phylloclade with the difference that cladode may be made-up of only one internode, *e.g., Asparagus* (satavar) or two internodes, *e.g., Ruscus.*

(d) Thorn : In some plants stem is modified into stiff, pointed unbranched or branched structures, thorns which sometimes have leaves, flowers, *e.g., Aegle marmelos* (bel), *Citrus* (lemon), *Punica granatum* (pomegranate), *Ulex, Duranta, Carissa,* etc. They perform defensive function.

- **Thorns are actually modified axillary buds or terminal buds and they possess vascular supply.**

(e) Bulbils : In some plants vegetative buds or floral buds modify into a swollen structure called bulbil. It separates

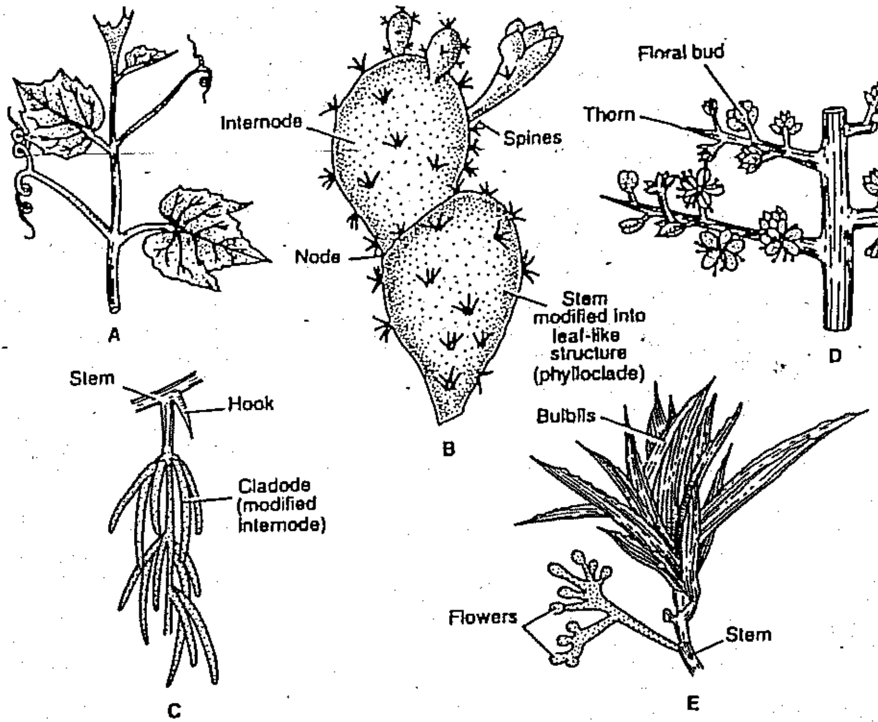

A
Internode
Spines
Node
Stem modified into leaf-like structure (phylloclade)
B
Floral bud
Thorn
D
Stem
Hook
Cladode (modified internode)
C
Bulbils
Flowers
Stem
E

Fig. 15.10. Aerial stem modifications A. Tendrils of *Vitis* B. Phylloclade of *Opuntia* C. Cladode of *Asparagus* D. Thorns of *Prunus* E. Bulbil of *Agave*

from the parent plant and on approach of favourable condition gives rise to a new plant, *i.e.*, it is an organ of vegetative reproduction, *e.g.*, *Agave, Oxalis, Dioscorea bulbifera* (yam), etc.

Functions of stem

Stem performs following functions:

(i). Generally the stem is aerial, strong which holds the plant upright. It bears branches, leaves, flowers and fruit.

(ii) It transports the absorbed water and minerals from the roots to different parts of the plant, sugars synthesized in leaves are transported to the roots by stem.

(iii) Stem either aerial or underground performs the function of storage.

(iv) Sometimes the stem also acts as a perenating organ, *e.g.*, corms, rhizomes, etc., as well as the organ of vegetative propagation.

THE LEAF

Leaf is the most important or main photosynthetic organ of the plant. It is a thin, flattened outgrowth of the plant arising from the node of the stem and having a bud in its axil.

According to the origin and function of leaves they can be grouped into following types:

(i) Cotyledonary leaves or Seed leaves : These are embryonic seed leaves which may be fleshy due to accumulation of food, *e.g.*, *Cicer arietinum* (gram) or thin, *e.g.*, *Ricinus*.

(ii) Hypsophylls or Bract leaves : These leaves contain flower or an inflorescence in their axil. Their function is to protect the flower buds. These are generally small and green in colour but in some cases like *Bougainvillea* and *Euphorbia*, these bracts become large and coloured.

(iii) Cataphylls : These are non-green scale leaves occuring on the underground stems having buds in their axils. Cataphylls also perform the function of protection.

(iv) Sporophylls : Different parts of the flower, *i.e.*, sepals petals, androecium, gynoecium are modified leaves or floral leaves. Sepals which are green in colour protect the flower while petals being coloured attract the insects for pollination.

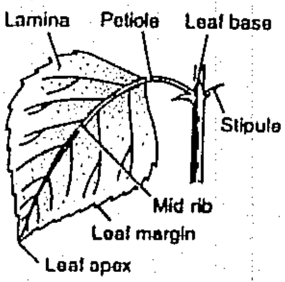


Fig. 15.11. Parts of a foliage leaf

(v) Foliage leaves : These are the leaves found on the main stem and branches. Foliage leaves are green in colour and perform the function of photosynthesis.

Different parts of a foliage leaf

A leaf consists of three parts, *i.e.*, leaf base, petiole and lamina.

(A) Leaf base

It is the basal portion by which the leaf is attached to the

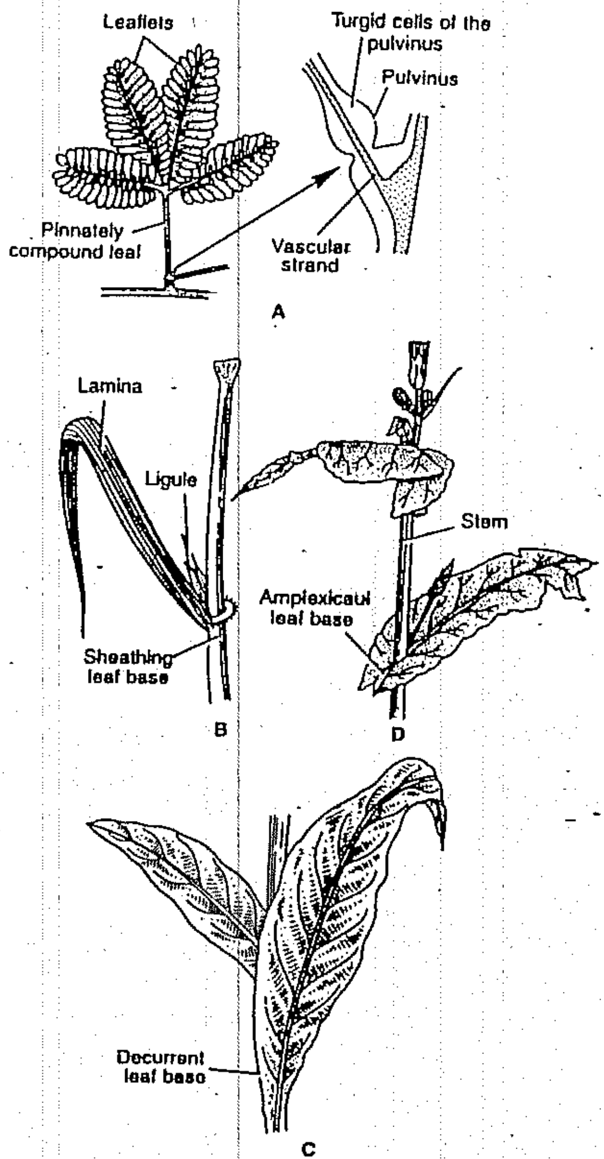


Fig. 15.12. Types of leaf bases A. Pulvinus of *Mimosa* leaf B. Sheathing leaf base of *Triticum* C. Decurrent leaf base of *Symphytum* D. Amplexicaul leaf base of *Sonchas*

stem or branch. There are different types of leaf bases. These are:

(i) **Pulvinus :** In some leaves the leaf base is swollen and hence the leaf is easy to pluck because of their weak attachment with stem, *e.g.*, *Mangifera* (mango), *Pisum* (pea), *Cicer* (gram), *Ficus* (banyan), etc.

(ii) **Sheathing:** In some leaves the leaf base expands forming a flat sheath which encloses the stem portion above node, *e.g.*, *Zea mays* (maize), *Saccharum officinarum* (sugar cane), *Musa paradisiaca* (banana), etc.

- In banana sheathing leaf bases forms a pseudostem or false stem while the actual stem is below the ground.

(iii) **Decurrent :** The leaf base in some plants becomes flat broad and winged covering the upper part of the node, *e.g.*, *Crotolaria*, *Symphytum*, *Laggera*, etc.

(iv) **Amplexicaul :** This type of sheathing leaf base encloses the stem completely, *e.g.*, *Polygonum*.

Stipules

In some plants leaf base consists of small appendages on both sides, these are called stipules. The leaves having stipules are termed as **stipulate** while the leaves without stipules are called **exstipulate**. Mainly stipules perform the function of protection of leaves. Stipules are classified either:

(I) According to the time period of their attachment, or,

(II) On the basis of structure and location.

(I) According to the time period of their attachment, stipules are of following types:

(i) **Caducous :** When stipules detach before the leaf unfolds, *e.g.*, *Michelia champaca*, etc.

(ii) **Deciduous :** These stipules detach just after the leaf unfolds, *e.g.*, *Cassia*, *Dilenia*, etc.

(iii) **Persistent :** Stipules which remain attached throughout life, *e.g.*, *Rosa indica* (rose), *Hibiscus rosa-sinensis* (gurhal), etc.

(II) According to the structure and location, stipules may be of following types:

(i) **Free lateral stipules :** Two free stipules occurring on both sides of the leaf base, *e.g.*, *Hibiscus rosa-sinensis* (china rose), *Gossypium* (cotton), etc.

(ii) **Adnate stipules :** These are two lateral stipules attached to the petiole with their posterior part, *e.g.*, *Rosa indica* (rose).

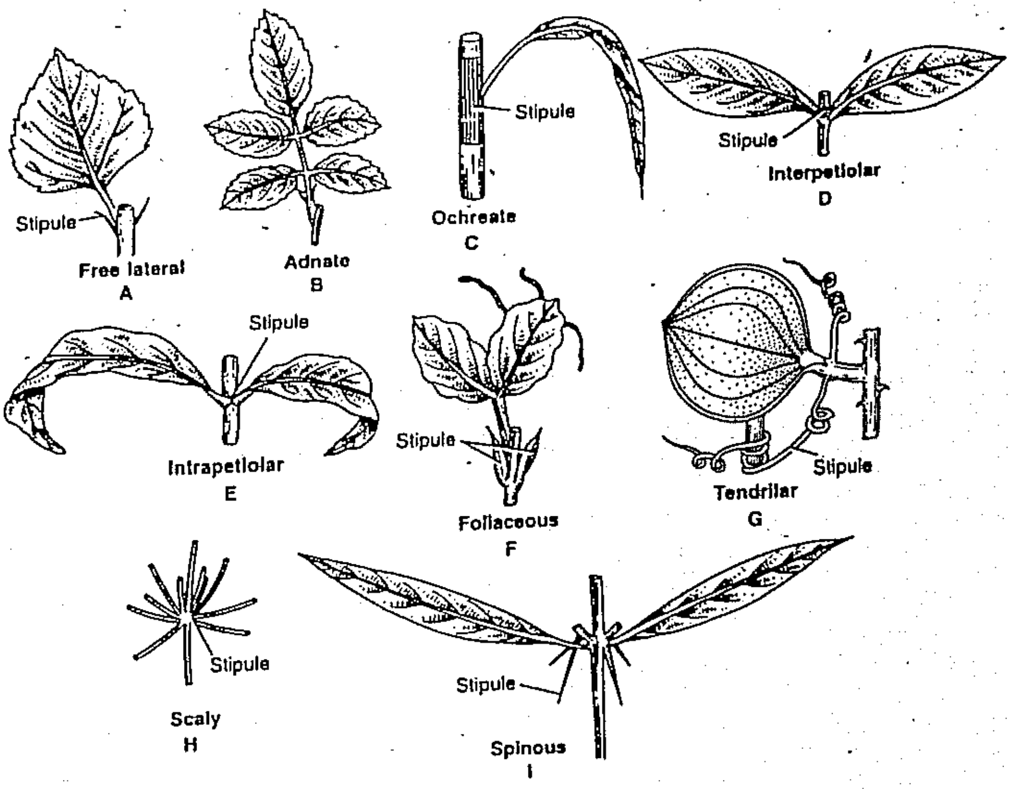


Fig. 15.13. Types of stipules A. Free lateral B. Adnate C. Ochreate D. Interpetiolar E. Intrapetiolar F. Foliaceous G. Tendrillar H. Scaly I. Spinous

(iii) Ochreate stipules : These are two in number and form a hollow tube which surrounds the upper part of node, *e.g., Rumex, Polygonum*, etc.

(iv) Interpetiolar stipules : These stipules occur between the petioles of opposite leaves and are two in number, *e.g., Ixora, Hamelia, Anthocephalus*, etc.

(v) Intrapetiolar stipules : Stipules occurring between petiole and stem, *e.g., Gardenia, Tabernemontana*.

(vi) Foliaceous stipules : These stipules are green and leaf like structures. Foliaceous stipules are two in number, *e.g., Lathyrus* (sweet pea).

(vii) Tendrillar stipules : Stipules are modified into thin, wiry structures called tendrils which help the plant in climbing up, *e.g., Smilax*.

(viii) Bud scales : These stipules are scaly which protect the leaf buds by surrounding them, *e.g., Artocarpus, Banyan*, etc.

(ix) Spiny stipules : When the stipules are modified into spines which may be long, *e.g., Mimosa, Acacia* or curved, *e.g., Zizyphus*. They perform the function of protection.

(B) Petiole or Leaf stalk

Petiole connects the lamina with the stem. It is small and green structure, the upper portion of which continues in the lamina forming midrib while lower portion forms the leaf base. Leaves lacking petiole are called sessile.

Petioles are of following types:

(i) Winged petiole : The petiole is modified into flattened, winged leaf life structure, *e.g., Citrus* fruits (orange, lemon), *Feronia*, etc.

(ii) Tendrillar petiole : Sometimes the petiole modifies into thin, wiry tendril and helps the plant to climb up, *e.g., Nepenthes, Nasturtium*.

(iii) Phyllode : In some plants the petiole performs the function of leaf by modifying into leaf like structure, *e.g., Acacia auriculaeformis* (Australian acacia), *Parkinsonia*, etc.

(iv) Floating petiole : The petiole becomes spongy and helps the plant in floating. This is also termed as bulbous petiole, *e.g., Eichhornia, Trapa*, etc.

(C) Lamina

Lamina is the green, flattened part of leaf performing the important functions of photosynthesis, transpiration and respiration. In the middle of the lamina, a thick midrib is present extending from petiole to the apex. The midrib gives rise to lateral or side branches which are again divided and a net like structure is visible in the lamina.

Shapes of lamina:

(i) Acicular : Lamina is long and pointed like a needle, *e.g., Allium cepa* (onion), *Pinus*, etc.

(ii) Lanceolate : In this type lamina is pointed or narrower at the ends while broad in the middle, *e.g., Nerium, Polyalthea*, etc.

(iii) Linear : The lamina is long and narrow having parallel margins, *e.g., Triticum* (wheat), *Oryza sativa* (rice) and many grasses.

(iv) Ovate : In this type lamina is egg-shaped having broad base with slight narrow top, *e.g.,* China rose, etc.

(v) Obovate : Shape of lamina is just opposite of ovate condition, *i.e.,* base is narrow while the top is broad, *e.g., Juglans regia* (walnut), *Prunus amygdalus* (badam).

(vi) Cordate : The base of lamina is broad and bilobed. Its shape is like a heart, *e.g.,* betel, banyan, *Tinospora*, etc.

(vii) Obcordate : Obcordate lamina is just opposite of cordate lamina. In this type instead of base the apex is broad and bilobed, *e.g., Oxalis, Bauhinia*, etc.

(viii) Reniform : Lamina is kidney-shaped, *e.g., Hydrocotyle*.

(ix) Lunate : In this type lamina is just like a half circle, *i.e.,* semicircular, *e.g., Passiflora, Adiantum*.

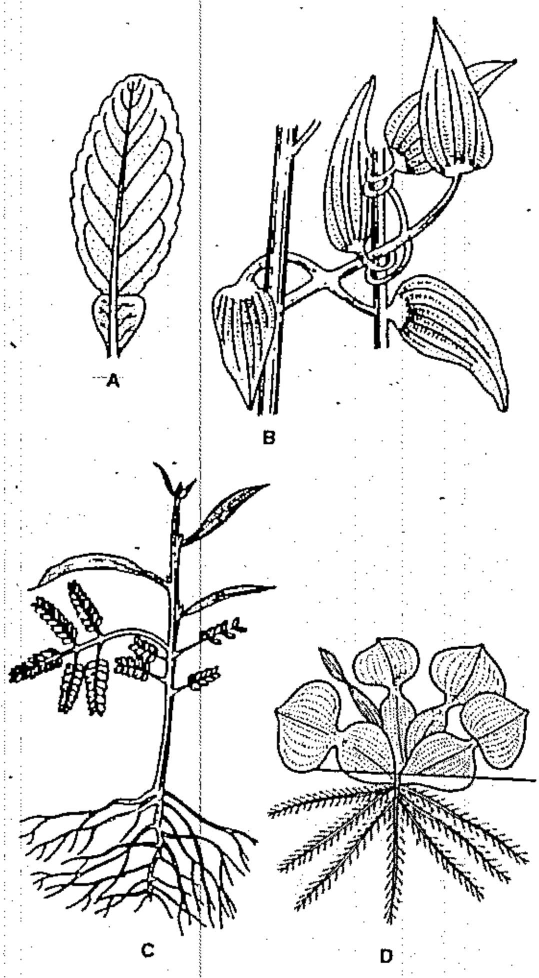


Fig. 15.14. Petiole types A. Winged petiole of *Citrus* B. Tendrillar petiole of *Clematis* C. Phyllode of *Acacia* D. Bulbous petiole of *Eichhornia*

(x) Oblong : Long and broad lamina with round apex, *e.g.*, banana.

(xi) Elliptical or Oval : In this type the middle portion of lamina is broad while the ends are narrow and oval, *e.g.*, *Psidium* (guava).

(xii) Sagittate : The lamina is triangular in shape, like an arrow head, *e.g.*, *Sagittaria*.

(xiii) Spathulate : The lamina is broad spoon shaped, *i.e.*, spatulate, *e.g.*, *Drosera*, *Calandula*, *Lipia*, etc.

(xiv) Tunicate : The base is narrow which increases in width towards the apex, *e.g.*, *Pistia*.

(iii) Caudate or Acuminate : Apex becomes long and narrow giving a tail like appearance, *e.g.*, *Ficus religiosa* (peepal).

(iv) Cuspidate or Spiny : In this type the lamina becomes hard and pointed like a spine, *e.g.*, *Agave*, *Phoenix dactylifera* (date palm), *Annanas squamosa* (ananas), etc.

(v) Mucronate : The apex is broad but ends into a sharp point, *e.g.*, *Vinca rosea*, *Cassia obtusifolia*, *Ixora*, etc.

(vi) Tendrillar : The apex modifies into a wiry, thin tendril which helps the plant in climbing, *e.g.*, *Gloriosa*.

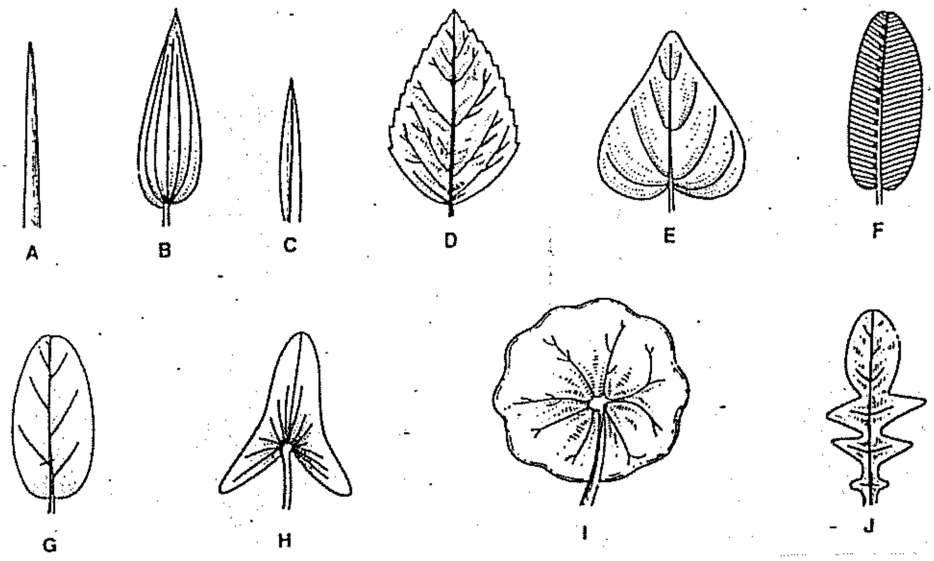


Fig. 15.15. Some shapes of leaf lamina A. Acicular B. Lanceolate C. Linear D. Ovate E. Cordate F. Oblong G. Elliptical H. Sagittate I. Rotund J. Lyrate

(xv) Orbicular or Rotund : In this type the lamina is spherical, *e.g.*, *Nelumbo nucifera* (lotus), *Nasturtium*, etc.

(xvi) Lyrate : The lamina consists of large terminal lobe and smaller lower lobe, *e.g.*, *Brassica campestris* (mustard), *Raphanus sativus* (radish), etc.

Apex of lamina : The apex of leaf may be of following types:

(i) Acute : In this type both the margins of lamina meet sharply at the apex forming an acute angle because of which it becomes pointed, *e.g.*, *Mangifera indica* (mango), *Hibiscus rosa-sinensis* (China rose), etc.

(ii) Obtuse : Both the margins of lamina meet at apex making obtuse angle and the apex becomes rounded, *e.g.*, banyan.

(vii) Cirrhose : The apex ends into short thin structure, *e.g.*, *Musa paradisiaca* (banana).

(viii) Retuse : Broad apex having a notch, *e.g.*, *Oxalis*, *Pistia*, *Clitoria*, etc.

(ix) Truncate : Both the margins are sharply cut at sides before meeting in centre, *e.g.*, *Paris polyphylla*.

(x) Emarginate : In this type a deep notch divides the apex into two parts, *e.g.*, *Oxalis*, *Bauhinia*, etc.

Margin of lamina : Margins of lamina may be of following types:

(i) Entire : The lamina having smooth margins, *i.e.*, without any cuts or incisions, *e.g.*, *Mangifera indica* (mango), *Smilax*, *Ficus* (banyan), etc.

(ii) Wavy or Sinuate : In this type the margins are wavy, *e.g.*, *Polyalthia*, *Saraca*, etc.

(iii) Serrate : Margins of lamina are cut like the teeth of a saw directing upwards, *e.g., Rosa indica, Hibiscus rosa-sinensis* (China rose), margosa, etc.

(iv) Biserrate : In this type the margins have incisions which are further incised, *e.g., Elm.*

(v) Dentate : The incisions or teeth make right angles with margin extending outwards, *e.g., Nymphaea.*

(vi) Bidentate : The margin is incised and the teeth are again extended outwards.

(vii) Crenate : In this type the teeth of incised margin are round in shape, *e.g., Bryophyllum, Hydrocotyle*, etc.

(viii) Bicrenate : In this type the incised round teeth of margin are again cut into small round teeth.

(ix) Retroserrate : The margin is incised and the teeth are extending downwards.

(x) Spiny : The margin of lamina is sharp like spines, *e.g., Argemone.*

(xi) Lobed : Margin of the lamina is deeply incised and small lobes are formed, *e.g., Brassica rapa* (mustard), *Raphanus sativus* (radish).

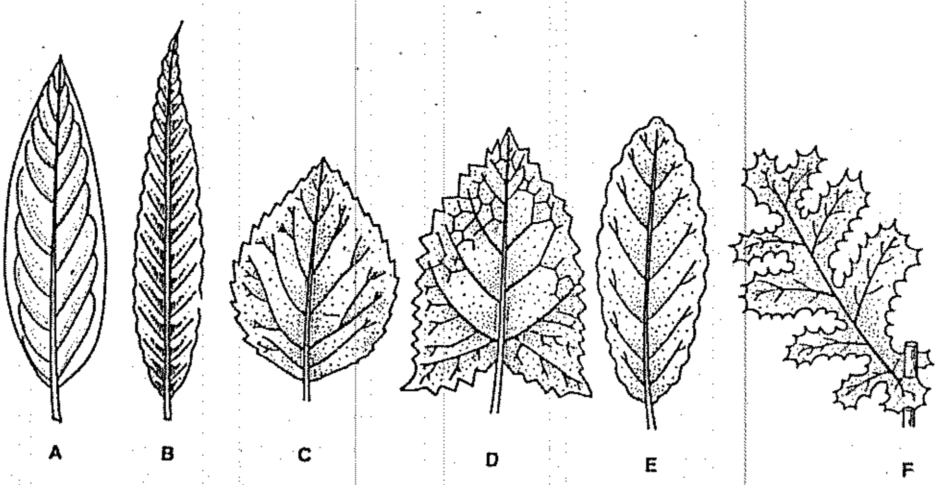


Fig. 15.16. Types of margins of leaf lamina A. Entire B. Undulate C. Serrate D. Dentate E. Crenate F. Spinous

Venation

In the leaves, the arrangement of main vein and its branches is known as venation. Venation may be of two types; parallel venation and reticulate venation.

(A) Parallel venation

In parallel venation the veins run parallel to each other. This type of venation is found generally **in monocotyledons** and rarely in some dicotyledonous leaves, *e.g., Eryngium, Calophyllum*, etc.

Depending upon the number of midribs the parallel venation is divided into two types:

(a) Parallel pinnate or unicostate : Only one midrib is present which gives out lateral veins running parallel to each other, either towards the apex or margins, *e.g.*, canna, banana, etc.

(b) Parallel palmate or multicostate : In this type of venation, many midribs are formed from the petiole. Palmate venation is of two types:

(i) Convergent type : Different midribs running parallel to each other converge at the apex, *e.g., Triticum aestivum* (wheat), *Bambusa*, grasses, etc. (Fig. 15.17)

(ii) Divergent type : In this type a number of midribs extend towards the margins, *e.g., Borassus*, Palms, etc.

(B) Reticulate venation

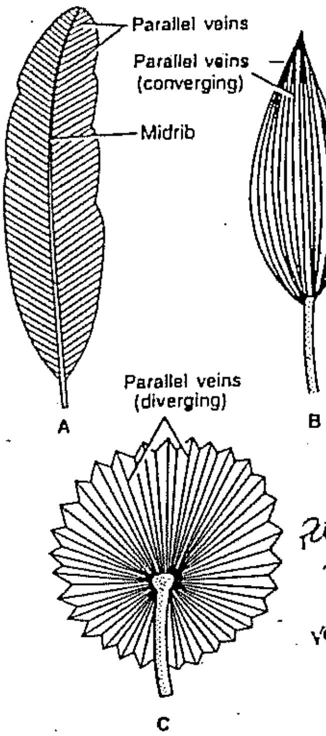
In reticulate venation the main vein by forming a number of branches gives rise to a net like structure in the leaf. It is generally found **in dicots** and rarely in monocots, *e.g., Smilax, Alocasia, Dioscorea*, etc. Reticulate venation is of two types:

(a) Reticulate pinnate or unicostate : In this type of venation only one midrib is present which gives out lateral veins running parallel to each other either towards the apex or margins, *e.g., Mangifera indica* (mango), *Ficus* (peepal), etc.

(b) Reticulate palmate or multicostate : There are more than one main veins arising from the petiole and extend towards apex.

(i) Convergent type : A number of main veins arising from the petiole spread upward and converge at the apex, *e.g., Zizyphus jujuba* (ber), *Cinnamomum camphora* (kapoor), nuxvomica, etc.

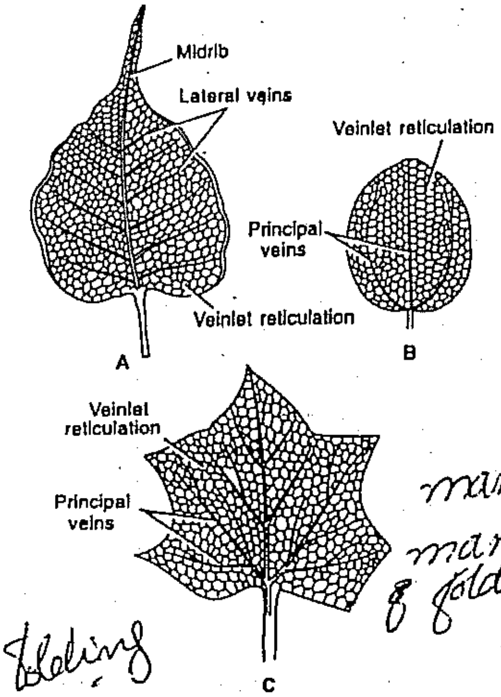
(ii) Divergent type : In this type different main veins arising from the tip of petiole diverge towards the periphery, *e.g., Borassus, Cucumis sativus* (cucumber), *Ricinus communis* (castor), etc.



Parallel veins.

veins

Fig. 15.17. Types of parallel venation A. Unicostate in banana B. Multicostate convergent in bamboo C. Multicostate divergent



manner

manner & folding

folding

Fig. 15.18. Types of reticulate venation A. Unicostate in peepal B. Multicostate convergent in *Zizyphus* C. Multicostate divergent in Castor

Vernation and ptyxis

The arrangement of leaves in a bud with respect to each other is called **vernation.**

Ptyxis, on other hand, is the manner of folding of an individual leaf in bud condition, *e.g.*, **circinate** ptyxis (folding or rolling from apex to base as in ferns); **conduplicate** ptyxis (folding of leaf over midrib as in *Bauhinia* and *Psidium, i.e.*, guava); **involute** ptyxis (margins of leaf rolled on upper surface as in *Colocasia*); **revolute** ptyxis (margins of leaf rolled on lower surface) and **crumpled** ptyxis (irregular folding of leaf as in cabbage, *i.e., Brassica oleracea* var. *capitata),* etc.

Simple and compound leaves

Depending upon the incision of lamina, leaves are of two types, *i.e.*, simple and compound.

(A) Simple leaf

A leaf having a single lamina with smooth or incised margins. But the marginal incision is not deep upto midrib, *e.g., Mangifera indica* (mango), *Psidium guajava* (guava), *Carica papaya* (papaya), *Ficus* (banyan), etc., on the basis of the direction of incision the simple leaf may be of two types:

(a) **Pinnate simple leaf:** The incisions point towards the midrib, *e.g., Raphanus sativus* (radish).

(b) **Palmate simple leaf:** The incisions are pointed towards the petiole, *e.g., Ricinus.*

(B) Compound leaf

In compound leaf the lamina is incised upto midrib or petiole because of which lamina is divided into a number of parts called leaflets. Compound leaves are of two types depending upon the incision, *i.e.*, pinnate compound leaf and palmate compound leaf.

(a) **Pinnate compound leaf:** The incisions of lamina are pointed towards the midrib now termed as **rachis.** The leaflets are present laterally in opposite manner or alternately. Pinnate compound leaf may be of following types:

(i) **Unipinnate:** In unipinnate compound leaf the leaflets are directly associated with the rachis.

- Some leaves having even number of leaflets are termed as **paripinnate,** *e.g., Cassia, Cicer* (gram), *Tamarindus indica* (tamarind), etc, while the leaves having odd number of leaflets are termed as **imparipinnate,** *e.g., Rosa indica* (rose), *Azadirachta indica* (neem), etc.

(ii) **Bipinnate:** In this type, the rachis is subdivided, *i.e.*, the secondary leaflets are formed on both sides of the primary leaflets, *e.g., Mimosa pudica, Acacia,* etc.

(iii) **Tripinnate:** In tripinnate compound leaf the rachis divides to form primary leaflets which gives rise to secondary leaflets which inturn forms tertiary leaflets, *i.e.*, divides thrice, *e.g., Moringa, Oroxylon,* etc.

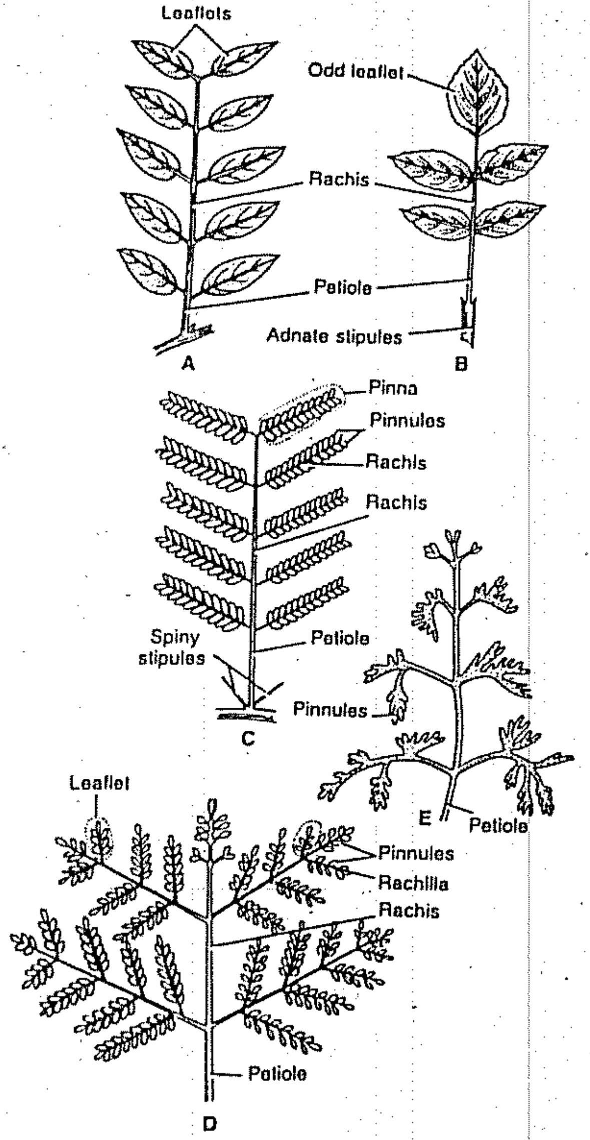

Leaflets
Odd leaflet
Rachis
Petiole
Adnate stipules
A
B
Pinna
Pinnules
Rachis
Rachis
Spiny stipules
Petiole
C
Pinnules
E
Petiole
Leaflet
Pinnules
Rachilla
Rachis
Petiole
D

Fig. 15.19. Types of pinnate compound leaves A. Paripinnate leaf in *Cassia* B. Imparipinnate leaf in *Rosa* C. Bipinnate leaf in *Acacia* D.Tripinnate leaf in *Moringa* E. Decompound leaf in *Daucus*

(iv) Decompound : In this type division of rachis occurs more than three times, ***e.g.***, *Coriandrum* (coriander), *Daucus carota* (carrot), etc.

(b) Palmately compound leaf : The incisions of lamina are pointed towards the base and are connected to the petiole tip.

Palmately compound leaf is of five types:

(i) Unifoliate : In this type a single leaflet is formed at the tip of petiole, *e.g.*, *Citrus limon* (lemon), etc.

(ii) Bifoliate : In bifoliate compound leaf, two leaflets are formed at the tip of petiole, *e.g.*, *Balanites, Bignonia, Princepia, Hardwickia*, etc.

(iii) Trifoliate : In this type three leaflets are formed at the tip of petiole, *e.g.*, *Aegle marmelos* (bel), *Medicago, Oxalis*, etc.

(iv) Quadrifoliate : Four leaflets are formed at the tip of petiole, *e.g.*, *Paris quadrifolia, Marsilea*, etc.

(v) Multifoliate : More than four leaflets are formed at the tip of petiole, *e.g.*, *Gynandropsis, Cleome, Bombax*, etc.

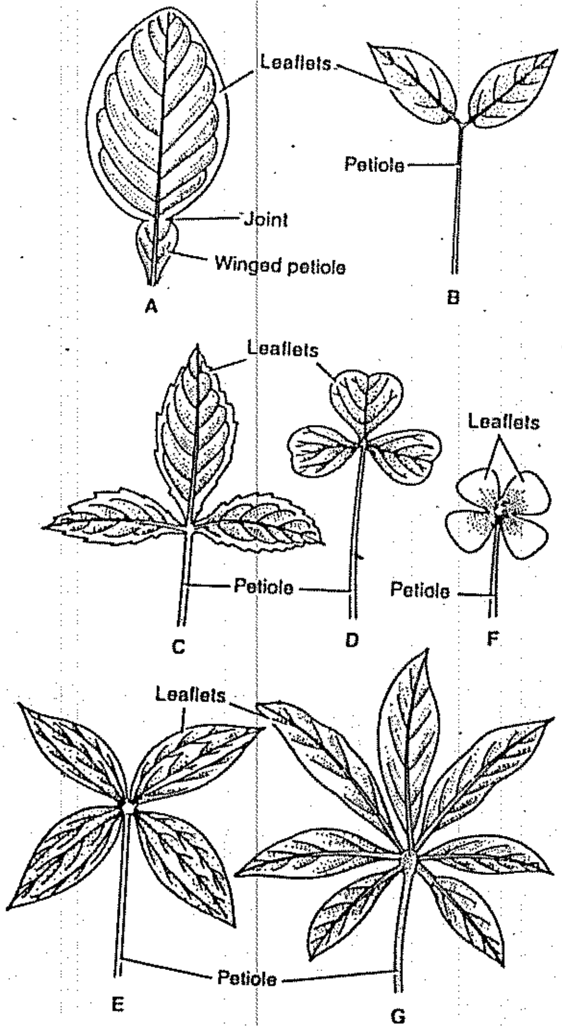

Leaflets
Petiole
Joint
Winged petiole
A
B
Leaflets
Leaflets
Petiole
Petiole
C
D
F
Leaflets
Petiole
E
G

Fig. 15.20. Types of palmate compound leaves A. Unifoliate leaf in *Citrus* B. Bifoliate leaf of *Hardwickia* C. Trifoliate leaf in *Aegle* D. Trifoliate leaf of *oxalis* E. Quadrifoliate leaf of *Paris* F. Quadrifoliate leaf of *Marsilea* G. Multifoliate leaf of *Salmalia*

Phyllotaxy

Phyllotaxy means the arrangement of leaves on both main stem and branches. This arrangement is made to allow the leaves enough light for photosynthesis.

Mainly the leaves are arranged in the following ways:

(a) Alternate arrangement : In this type each node gives rise to single leaf and these are arranged alternately giving a spiral form, *e.g., Mangifera indica* (mango), *Hibiscus rosa-sinensis* (gurhal), *Brassica campestris* (mustard), *Nicotiana tabacum* (tobacco), etc.

(b) Opposite : Each node gives rise to two leaves, arranged opposite to each other. Opposite phyllotaxy is of following two types:

(i) Opposite superposed : The position of two leaves of each node resembles with the leaves of upper node, *e.g., Eugenia, Quisqualis, Ixora*, etc.

(ii) Opposite decussate : The leaves of a node are at right angles to the leaves of next node, *i.e.*, lower or upper node, *e.g., Calotropis procera, Ocimum*, etc.

- In guava (*Psidium guajava*) both types of arrangement, *i.e.*, opposite superposed in horizontal branches and opposite decussate in vertical branches are found.

(c) Whorled : In this type of arrangement more than two leaves are formed from each node, which are arranged in a whorl, *e.g., Alstonia, Nerium, Vangueria*, etc.

Modifications of leaves

Beside the primary function of photosynthesis, the leaves perform various functions because of which they are modified into different forms. Some of them are:

(i) Leaf tendrils : In some plants the different parts of a leaf are modified into tendrils which help the plant in climbing up. In *Lathyrus aphaca* (wild pea) whole leaf while in *Pisum sativum* (sweet pea) the apical leaflets are modified into tendrils.

The other parts of a leaf modified are, leaf tip in *Gloriosa*, petiole in *Clematis*, terminal leaflets in *Narvelia*, stipules in *Smilax*, etc.

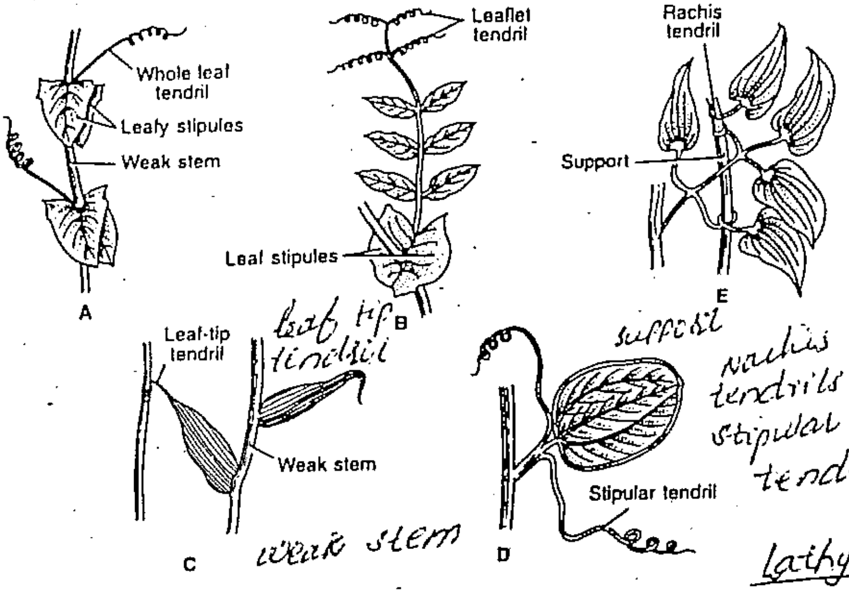

Whole leaf tendril
Leafy stipules
Weak stem
A
Leaflet tendril
Leaf stipules
B
Rachis tendril
Support
E
Leaf-tip tendril
Weak stem
C
Stipular tendril
D
leaf tip tendril
weak stem
support
rachis tendrils
stipular tendrils
Lathyrus odoratus

Fig. 15.21. Types of leaf tendrils A. Whole leaf tendril of *Lathyrus aphaca* B. Leaflet tendril of *Lathyrus odoratus* C. Leaf tip tendrils of *Gloriosa* D. Stipular tendril of *Smilax* E. Petiole and rachis tendrils of *Clematis*

Petiole and rachis tendrils 8-

(ii) Leaf spines : Either for the protection of plant or to lessen the rate of transpiration in xerophytic plants, the leaves modify into sharp, pointed spines. Sometimes other parts of leaf also modify into spines, *e.g.*, apex of leaf in *Phoenix* and

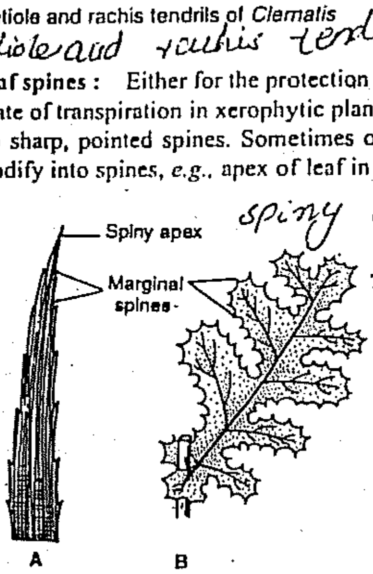

Spiny apex
Marginal spines
A
B
spiny apex
marginal spines.

Fig. 15.22. Leaf spines A. *Aloe* B. *Argemone*

Yucca, leaf margin in *Argemone*, both apex and margin in *Aloe barbedense*, stipules in *Acacia*, *Zizyphus jujube*, etc.

- o (Spines are actually leaf modifications and they generally have a bud in their axils).

(iii) Phyllode : In some plants the leaf or lamina falls off and the petiole modifies into leaf like structure. It also performs the function of synthesis of food, *e.g.*, *Acacia auriculiformis* (Australian acacia), *Parkinsonia*, etc.

innately
ompound
leaf.

hyllode

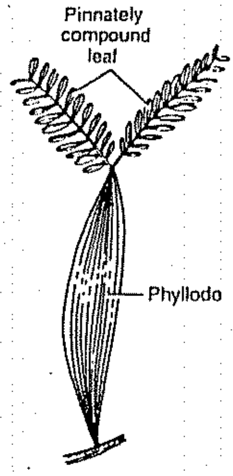


Fig. 15.23. Phyllode of *Acacia*

(iv) Scale or Protective leaves : In some plants the leaves modify into hard scaly leaves which protect the vegetative bud by covering them, *e.g.*, *Ficus*, *Artocarpus*, *Casuarina*, etc.

(v) Leaf hooks : Sometimes the leaflets or another parts of leaf modify into pointed, hard, sharp hooks which help the plant in climbing up, *e.g.*, *Bignonia unguiscati*, *Asparagus*, etc.

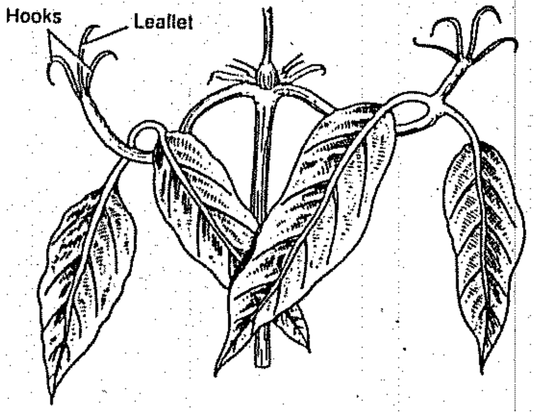


Fig. 15.24. Leaflet hooks of *Bignonia*

(vi) Leaf roots : In some water plants, *e.g.*, *Salvinia* (water fern) the leaves beside performing the function of leaf also form roots. Out of three leaves arising from a node, one gets converted into root and remaining two performs the function of leaf.

(vii) Leaf pitchers : In pitcher plant *Nepenthes* the lamina forms a pitcher like structure. The upper or apical portion of leaf forms the lid of pitcher and the flat basal part is the leaf base. The petiole modifies into thin wiry coiled tendril like structure which held the pitcher vertically. When some insect enters the pitcher it is trapped and digested by the juice present inside it.

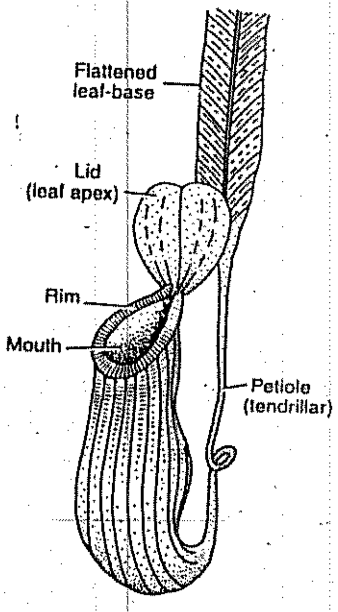


Fig. 15.25. Leaf pitcher of *Nepenthes*

Another example of pitcher like modification of leaves is of *Dischidia rafflesiana*. The pitcher is non-insectivorous and without lid. Water is stored inside the pitcher and is later on absorbed by adventitious roots.

(viii) Leaf bladder : In some plants the leaves modify to form bladder like structure which trap insects and then it is closed by a valve present on the mouth of bladder, *e.g.*, *Utricularia* (bladder wort).

(ix) Leaf tentacles : The leaf of sundew plant, *Drosera* bear minute hairs which have shinning, sticky substance at their tips (tentacles). When any insect sits on the leaf, it is covered by these hairs.

Functions of leaf

There are a number of functions performed by a leaf. Some of the important ones are:

(i) The major function of leaf is the synthesis of food so it is called as the **kitchen of the plant.**

(ii) The excessive amount of water is lost through the stomata present on leaves by the process of **transpiration.**

(iii) The stomata present on leaves are helpful in gaseous exchange.

(iv) Leaves perform the function of protection by modifying themselves into different forms, *i.e.*, into spines, scaly leaves, etc.

(v) Leaves of some plants help in vegetative propagation, *e.g.*, *Bryophyllum*, *Adiantum*, etc.

(vi) Leaves help the week plants to climb up by modifying themself into various forms, *i.e.*, hooks, tendrils, etc.

INFLORESCENCE

Flower is the most important part of the plant as it is concerned with sexual reproduction. The flowers may be present singly (*i.e.*, **solitary terminal** or **solitary axillary**) or may be present in groups arranged in definite manner. The **inflorescence** is actually **cluster or group of flowers or arrangement of flowers on floral axis** is called inflorescence. Inflorescence is of great taxonomic significance and plays an important role in identification of plants.

Inflorescence are basically of 3 main types:

(a) Racemose (Inflorescence of indefinite or indeterminate growth)

(b) Cymose (Inflorescence of definite or determinate growth)

(c) Some Special types of inflorescence.

- (For these types, see **Inflorescence** under heading **Important taxonomic terms** in 'Taxonomy of Angiosperms').

FLOWER

Flower is the reproductive part of the angiospermic plant and is defined as, 'the modified shoot with highly condensed internodes and leaves modified variously to perform different functions.' Calyx, corolla, androecium and gynaecium are the four whorls or parts of a typical flower.

- (For flower and its parts, See under **Important taxonomic terms** in Taxonomy of Angiosperms).

FRUIT

Morphologically, **ripened ovary** with its contents is called fruit.

- (See separate chapter – **Fruits and dispersal of seeds and fruits.**)

SEED

Morphologically, **ripened ovule** is known as seed. In other words, seed is mature, integumented megasporangium.

Seeds are characteristic of **Spermatophytes** (Gymnosperms and Angiosperms). The seed is having essentially **embryo**, which is miny or tiny future plant. A typical mature seed is having two main parts:

I. Seed coat

Outer, protective covering of the seed is called seed coat, which develops from integuments of ovule. In seeds developing from bitegmic ovules, there are two distinct layers in seed coat. The outer layer is thick, hard and leathery (developing from outer integument), called **testa**, whereas inner layer is thin and papery (developing from inner integument), called **tegmen**. In seeds developing from unitegmic ovules there is single layered seed coat. The seed coat performs usual protective function.

The seed is attached to the fruit wall or pericarp by means of a stalk called **funicle** or **funiculus**. The point of attachment of funiculus to the body of mature seed is called **hilum**. A small opening or pore called **micropyle** is present just below the hilum, which is the way of entry of water into the seed. As most of the ovules in angiosperms are inverted or **anatropous**, so a ridge called **raphe** is present just above the hilum, which represents fusion of funiculus with the seed coat or integuments.

II. Embryo

Embryo is the most important part of the seed, which represents miny or tiny future plant. The origin of embryo is from fertilized egg or zygote.

The embryo is having an embryonal axis or main axis called **tigellum**, to which one or two cotyledons (seed leaves) are attached, depending upon whether the seed is monocot or dicot. The portion of embryonal axis or tigellum below the point of attachment of cotyledons, is called **hypocotyl**, which bears **radicle** or future root at its tip. Similarly, portion of embryonal axis or tigellum above the point of attachment of cotyledons, is called **epicotyl**, which bears **plumule** (future shoot) at its tip.

In some seeds (*e.g.*, legumes), reserve food is stored in cotyledons, whereas in others (*e.g.*, cereals), there is special nutritive tissue called **endosperm**. The seeds having endosperm are called **endospermic** or **albuminous seeds**, *e.g.*, cereals, castor, etc., whereas seeds in which endosperm is fully consumed by embryo and no endosperm is left, are called **non-endospermic** or **ex-albuminous** seeds, *e.g.*, gram, pea, sem, cucumber, tamarind, etc. The reserve food materials in seeds may be carbohydrates (*e.g.*, wheat, rice) or proteins (legumes) or fats (castor, peanut, sunflower), etc.

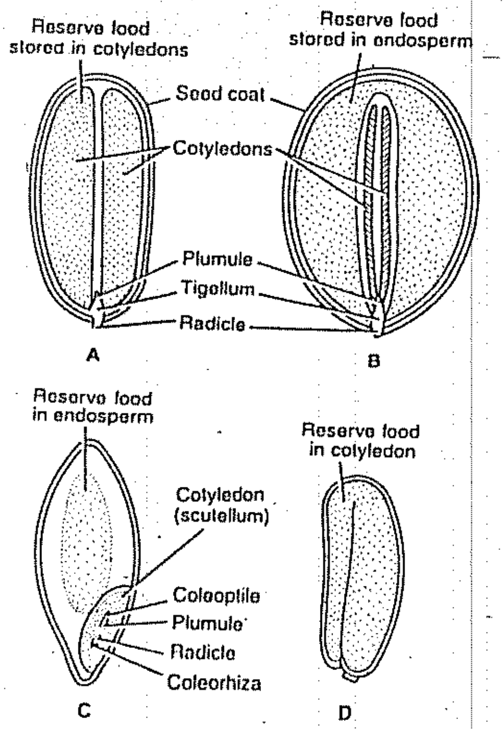

Reserve food stored in cotyledons
Reserve food stored in endosperm
Seed coat
Cotyledons
Plumule
Tigellum
Radicle
A
B
Reserve food in endosperm
Reserve food in cotyledon
Cotyledon (scutellum)
Coleoptile
Plumule
Radicle
Coleorhiza
C
D

Fig. 15.26. Typical seed structure A. A dicot non-endospermic seed B. A dicot endospermic seed C. A monocot endospermic seed D. A monocot non-endospermic seed

- (All the structures inside the seed coat constitute **Kernel**).
- In monocot embryo, there is a single cotyledon called **scutellum**, which is attached to mid-part of embryonal axis on its lateral side. On opposite side of scutellum is present a tongue shaped outgrowth called **epiblast** (*e.g.*, wheat). Further there is a covering or sheath of radicle called **coleorhiza** and sheath of plumule called **coleoptile**.
- In dicot albuminous seed called **castor** (*Ricinus communis*), there is a specific outgrowth called **caruncle** or **strophiole**, present over hilum. It is formed by proliferation of cells of outer integument at tip. Caruncle is somewhat **spongy** and helps in absorption of water during germination of seed.

Endospermic dicot seeds : *e.g.*, castor, papaya, cotton.

Non-endospermic dicot seeds : *e.g.*, gram, bean, pea, cucumber, tamarind.

Endospermic monocot seeds : *e.g.*, maize, rice, wheat.

Non-endospermic monocot seeds : *Pothos* (money plant), *Vallisneria, Alisma, Amorphophallus.*

Seed germination

The formation of seedling from dormant embryo of seed after resumption of its active growth, is called germination.

During germination, the seeds absorb water through micropyle, swell up and seed coat is softened. Respiration rate is increased in germinating seeds. The enzymes secreted by embryo convert insoluble reserve food substances into soluble substances, which can be utilized by growing embryo. Cell division activity starts in radicle and plumule. **The radicle first** comes out of seed coat and grow downwards (into soil) to form **root**. After this **plumule** comes out rupturing the seed coat to form shoot and thus seedling is formed.

Germination is basically of two types, depending upon behaviour of cotyledons:

1. **Epigeal germination :** Here due to hypocotyl growth or elongation, cotyledons are pushed out of soil. This is called **epigeal germination**. This type of germination occurs in cotton, papaya, castor, onion, cucurbits, tamarind, French bean, mustard, etc. In some cases, these above ground cotyledons become green leaf like (cotyledonary leaves) and perform photosynthetic function till the seedling assumes independency (*e.g.*, castor, cotton, onion, papaya, etc.). In other plants, cotyledons do not assume leaf like shape and fall off (*e.g.*, French bean and tamarind).

French bean & Tamarind

Cotyledons

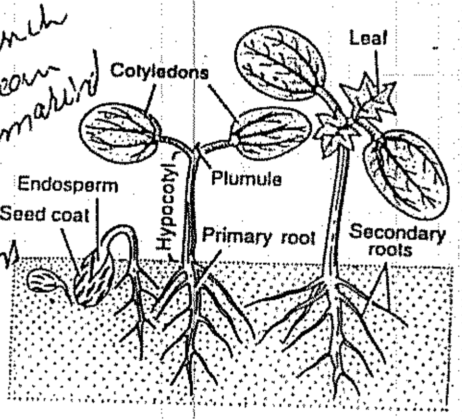

Leaf
Cotyledons
Endosperm
Seed coat
Hypocotyl
Plumule
Primary root
Secondary roots

Fig. 15.27. Epigeal seed germination in *Ricinus communis*

Epogeal Seed germination

2. **Hypogeal germination :** Here due to first epicotyl elongation, plumule comes out of the ground and cotyledons remain underground. This is called **hypogeal germination.** This type of germination occurs in most of the monocotyledons and few dicotyledons, *e.g.*, **maize, rice,** wheat, coconut, gram, pea, peanut and mango, etc.

- A special type of seed germination is characteristic of **mangrove vegetation**, found in muddy, saline conditions, *e.g.*, *Rhizophora*,—*Avicennia*, *Ceriops*, *Breguira*, *Sonneratia*, etc. Here there is no resting period of embryo and seed germination occurs inside the fruit, while it is attached to the parent plant, *i.e.*, *in situ* germination. The seedling is separated from parent plant (not seed), which is established in the mud with the help of lateral roots developing from basal end of radicle. This is called viviparous germination or **vivipary**.

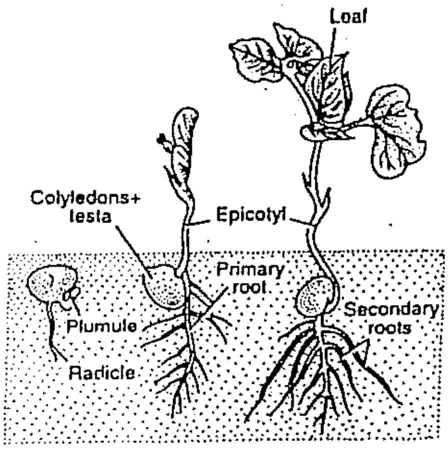


Fig. 15.28. Hypogeal seed germination in pea

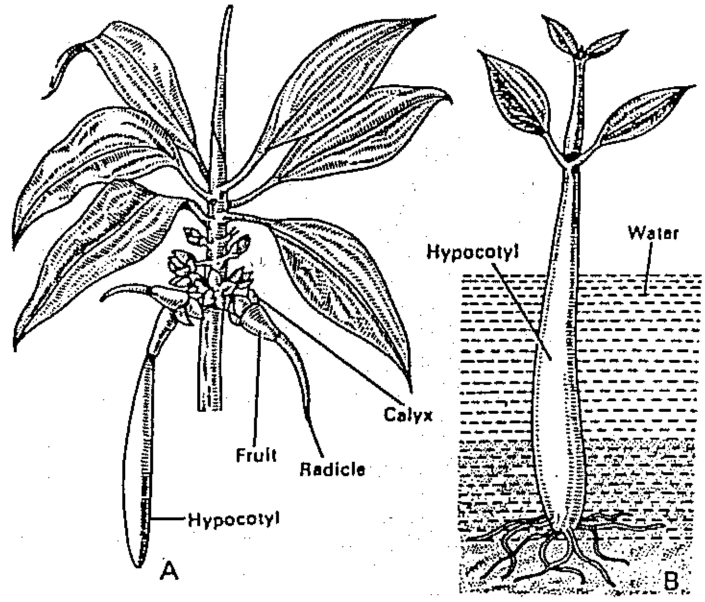


Fig. 15.29. Viviparous germination in *Rhizophora*

Conditions necessary for seed germination

(A) **External conditions or factors:**

1. **Moisture or Water :** It is primary condition for seed germination. Due to hydration of protoplasm, various physiological processes start. Further seed coat becomes soft as a result of imbibition of water.

2. **Oxygen :** This is second essential condition for seed germination, as O_2 is necessary for respiration and other physiological activities.

3. **Optimum temperature :** Best temperature for seed germination is 25–30°C, although different seeds germinate between 0–50°C.

Light, though not necessary for germination but in presence of light, germination is better. Further, there are some seeds like *Lactuca sativa* (Lettuce), which germinate only in presence of light, are called **photoblastic seeds**.

(B) **Internal factors:**

1. **Viability of seeds :** Germinating ability of the seed is called its viability. Only viable seeds are able to germinate. As the viability expires, the embryo dies and seed looses its capacity of germination. Viability of seeds varies from species to species.

- Longest seed viability is reported in *Nelumbo nucifera* (= *Nelumbium speciosum*) or **Indian lotus** (Kamal). Here the viability is reported to be more than two hundred years.

2. **Food availability :** Sufficient amount of food is required for growing embryo. The source of this food is cotyledons or endosperm or perisperm (remnant of nucellus).

3. **Completion of dormancy period :** Many seeds require a dormancy or resting period after harvesting. These seeds will not germinate without undergoing this resting period.

Seed dormancy

Viable seeds of some plants are unable to germinate even after getting all the necessary conditions. This inability of viable seeds to germinate even under favourable conditions, is called dormancy of seeds. This is considered to be due to some barriers or blocks inside the seeds.

Some common causes of seed dormancy are:

1. **Mechanically hard seed coat**, which does not allow proper growth of embryo inside it, *e.g.*, *Brassica campestris*.

2. **Presence of impermeable (impervious) seed coat to H_2O**, *e.g.*, many seeds of legumes.

3. **Presence of impermeable seed coat to oxygen**, *e.g.*, *Xanthium* (cocklebur).

4. **Presence of immature or rudimentary embryo.**
5. **Presence of embryos requiring after ripening dry-storage.**
6. **Presence of germination inhibitors** like ABA (abscisic acid) and phenolics, etc., in seed coat or fruit pulp, *e.g.*, in **tomato**, inhibitor is present in fruit pulp.
7. **Dormancy due to light requirement :** Photoblastic seeds, *e.g.*, *Lactuca sativa* (lettuce) do not germinate in absence of light.

Methods for overcoming or Breaking dormancy

1. **Mechanical scarification :** Seed coat is weakened by use of abrasives like sand and by making scratches.
2. **Chemical scarification :** Seed coat weakening is done by acid treatments.
3. Alternating high and low temperature treatment.
4. Low temperature treatment.
5. Exposure to light.
6. Providing high pressure.
7. Alcohol washing of seeds so as to remove inhibitors in seed coat, etc.
8. Soaking of seeds in some chemicals like **thiourea** and KNO_3, etc.

MULTIPLE CHOICE QUESTIONS

1. Tap root system is developed from:
   (a) Plumule
   (b) Radicle
   (c) Any part of the plant body
   (d) Hypocotyl
2. In onion, underground swollen edible portion is:
   (a) Root (b) Bulb
   (c) Underground stem (d) Rhizome
3. Photosynthetic function of opuntia is carried out by:
   (a) Corm (b) Phylloclade
   (c) Phyllode (d) Bulb
4. Most of our trees grow faster in:
   (a) Autumn (b) Summer
   (c) Winter (d) Spring
5. Single cotyledon of a monocot is: **(Raj. PMT 1991)**
   (a) Plumule (b) Mesocotyl
   (c) Coleorrhiza (d) Scutellum

*6. Prickles in rose are:
   (a) Modified leaves (b) Accessory buds
   (c) Exogenous in origin (d) Endogenous in origin
7. The thick roots that hang down from the banyan tree are called: **(BHU 1995; CPMT 2002)**
   (a) Butteress roots (b) Pneumatophores
   (c) Prop roots (d) Stilt roots
8. Catkin is type of:
   (a) Placentation (b) Inflorescence
   (c) Venation (d) Phyllotaxy
9. Cyathium inflorescence is found in:
   (a) *Morus* (b) *Dorstenia*
   (c) *Ficus* (d) *Euphorbia*
10. Seeds of gram are:
    (a) Exalbuminous epigeal
    (b) Exalbuminous hypogeal
    (c) Albuminous and epigeal
    (d) Albuminous and hypogeal
11. In legumes reserve food material is stored in: **(CPMT 1994)**
    (a) Fruit walls (b) Seed coat
    (c) Cotyledon (d) Radicle
12. Free lateral stipules occur in:
    (a) Cruciferae (b) Malvaceae
    (c) Papilionaceae (d) Solanaceae
13. Stilt roots are found in: **(Raj. PMT 1991)**
    (a) Banyan (b) *Pothos*
    (c) *Cuscuta* (d) *Pandanus*
14. The leaves obtain air through:
    (a) Cell wall (b) Cuticle
    (c) Stomata (d) Chlorophyll
15. Aquatic plants have:
    (a) Well developed stomata
    (b) Well developed aerenchyma
    (c) Well developed roots
    (d) Well developed xylem
16. Epigeal germination is found in:
    (a) Maize (b) Wheat
    (c) Pea (d) Castor
17. The inflorescence in Gramineae is a:
    (a) Raceme (b) Spike
    (c) Spikelet (d) Thyrsus
18. Verticillaster inflorescence is found in:
    (a) Leguminosae (b) Cruciferae
    (c) Compositae (d) Labiatae
19. In which of the following plants, cotyledons remain underground during germination?
    (a) Wheat (b) Gram
    (c) Bean (d) Castor

*20. The most appropriate definition of a seed in terms of its homologous organs found in spore producing land plant is:
    (a) A seed is an integumented sporangium with a single functional spore
    (b) A seed is an integumented indehiscent megasporangium with a functional megaspore
    (c) A seed is an integumented bud containing an egg
    (d) None of the above
21. *Ruscus* and cocoloba (*Muehlenbeckia*) furnish good example of: **(Raj. PMT 1992)**
    (a) Insectivorous plants (b) Tendril climber
    (c) Phylloclade (d) Phyllode

*22. Time interval between the appearance of two successive leaves or pairs of leaves is termed: **(EAMCET 1990)**
    (a) Hypsophyll (b) Plastochron
    (c) Cataphylls (d) Branchyblast
23. Leaf tip tendrils are found in:
    (a) *Pisum* (b) *Gloriosa*
    (c) *Smilax* (d) *Hibiscus*
24. One of the following is not essential for germination: **(CPMT 1994)**
    (a) Air (b) Light
    (c) Water (d) Temperature
25. Hypanthodium is characteristic inflorescence of:
    (a) *Ficus* (b) Pineapple
    (c) Mulberry (d) Poinsettia
26. Lateral root branches arise from parent root by the formation of roots primordia by division of: **(CPMT 1991)**
    (a) Pericycle cell opposite to protoxylem
    (b) Endodermis cell opposite to protoxylem
    (c) Cortical cells opposite to protoxylem
    (d) Pericycle cells lying between two Protoxylem

*27. In which of the following stem is most reduced?
    (a) Rhizome (b) Corm
    (c) Phylloclade (d) Bulb

28. Which of the following possesses winged seeds and exhibits wind dispersal?
(a) Acer (b) *Hiptage*
(c) *Shorea* (d) *Moringa*

29. The functions of velamen is: **(CPMT 1991)**
(a) Absorption of water from soil
(b) Absorption of moisture from air
(c) To help in transpiration
(d) None of the above

30. The leaf scar protects the plant from:
(a) Air (b) Heat
(c) Transpiration (d) Evaporation

31. Insectivorous plants grow in the soil which is deficient in:
(a) Calcium (b) Nitrogen
(c) Water (d) Magnesium

32. The fruit that develops from hypanthodium inflorescence is called: **(CPMT 1992)**
(a) Siliqua (b) Samara
(c) Syconus (d) Sorosis

33. Hypanthodium refers to a specialized type of: **(CBSE 1994)**
(a) Thalamus (b) Ovary
(c) Fruit (d) Inflorescence

34. Ginger is a stem and not a root because:
(a) It is bitter in taste
(b) It has nodes and internodes
(c) It is non-green in colour
(d) It stores food

35. Sweet potato is a modification of:
(a) Stem (b) Flowering axis
(c) Root (d) Bud

36. Total root parasite is:
(a) Loranthus (b) Rafflesia
(c) Viscum (d) Cuscuta

37. An example of parasitic plant that is also strictly epiphytic is:
(a) Viscum (Mistletoe) (b) Cuscuta (Dodder)
(c) Orobanche (d) Rafflesia

38. Which of the following features would distinguish a monocot from a dicot plant?
(a) Aestivation (b) Vernation
(c) Phyllotaxy (d) Venation

39. Heterotrophic nutrition is found in:
(a) *Opuntia* (b) *Drosera*
(c) *Vallisneria* (d) *Pistia*

40. Epidermal outgrowths are known as:
(a) Leaves (b) Trichomes
(c) Flower buds (d) Stomata

41. Fibrous roots develop in maize from:
(a) Lower nodes (b) Upper nodes
(c) Upper internodes (d) None of these

42. Inflorescence is the:
(a) Group of flowers
(b) Arrangement of flowers
(c) Arrangement of flowers on the floral axis
(d) None of the above

43. Both opposite superposed and opposite decussate phyllotaxy are present simultaneously on same plant in:
(a) *Quisqualis* (b) *Calotropis*
(c) *Psidium* (d) *Nerium*

44. Which of the following is a non-endospermic monocot seed? **(MDAT Bihar 1991)**
(a) *Plumbago* (b) *Alisma*
(c) Castor (d) Linseed

45. Which is not a modification of stem?
(a) Corm of *Colocasia* (b) Rhizome of ginger
(c) Pitcher of *Nepenthes* (d) Tuber of potato

46. If a growing plant is decapitated: **(CBSE 1994)**
(a) Leaves become yellow and have a tendency to fall off
(b) Growth stops
(c) Axillary buds are inactivated
(d) Axillary buds are activated

47. Which of the following is a modified green stem? **(AFMC 1990)**
(a) Rhizome (b) Bulbil
(c) Cladode (d) Phylloclade

48. Stilt roots are found in: **(MPPMT 1993)**
(a) Rice (b) Sugar cane
(c) Groundnut (d) Gram

49. In sweet potato food is stored in:
(a) Tuber (b) Stem
(c) Roots (d) Leaves

50. The most highly evolved type of inflorescence is: **(BHU 1990)**
(a) Hypanthodium (b) Spadix
(c) Polychasialcyme (d) Capitulum

51. Which is not an underground stem?
(a) Ginger (b) Rhizome
(c) Mango-ginger (d) None of these

52. Tunicated bulb is found in:
(a) Lily (b) Onion
(c) Garlic (d) *Oxalis*

53. Parallel venation is found in:
(a) Pea (b) Sarson
(c) Wheat (d) Hollyhock

54. Foliaceous or photosynthetic stipules occur in:
(a) Shoe flower (b) *Lathyrus/Pisum*
(c) Candytuft (d) Hollyhock

55. In which of the non-insectivorous plants, pitcher like modification of leaves is present?
(a) *Ficus* (b) *Dischidia*
(c) *Phoenix* (d) *Argemone*

*56. There is maximum growth in root: **(AFMC 1993)**
(a) Just behind the root apex
(b) At the root apex
(c) In the light
(d) In the dark

57. Vegetative reproduction through offset is common in:
(a) *Antigonon* (b) *Eichhornia*
(c) *Elodea* (d) *Amorphophallus*

58. In which of the following root, food is stored?
(a) Fibrous roots (b) Tap roots
(c) Respiratory roots (d) Fasciculated roots

59. Spadix inflorescence is found in: (BHU 1993)
(a) Paddy (b) Banana
(c) Mulberry (d) Gulmohar

60. Lianas are found in:
(a) Arctic regions (b) Tropical forests
(c) Deserts (d) Temperate forests

61. Dicotyledonous leaf showing parallel venation is of:
(a) *Smilax* (b) *Ranunculus*
(c) *Calaphyllum* (d) *Dioscorea*

62. In which of the following plants does the stem performs the functions of storage and perennation? (Manipal 1997)
(a) Groundnut (b) Ginger
(c) Wheat (d) Radish

63. Plant which burries its own seeds in the soil is:
(a) Groundnut (b) Sweet potato
(c) Potato (d) Onion

64. Myrmecophily is a beneficial association between some flowering plants and:
(a) Mycoplasma (b) Ants
(c) Bacteria (d) Virus

65. In which of the following hooked climbers are found?
(a) *Lathyrus* (b) *Artabotrys*
(c) *Gloriosa* (d) *Quisqualis*

66. Seeds are regarded products of sexual reproduction because they:
(a) Can be stored for long time
(b) Are result of fusion of pollen tube
(c) Are result of fusion of gametes
(d) Give rise to new plants

67. In Musaceae the inflorescence is:
(a) Spike (b) Head
(c) Capitulum (d) Spadix

68. Pneumatophores (breathing roots) are usually present in: (CPMT 1993)
(a) Xerophytes
(b) Epiphytes
(c) Mangrove plants (*Avicennia*)
(d) Hydrophytes

69. Potato tuber is a modified:
(a) Root (b) Stem
(c) Stolon (d) Bulb

70. *Cuscuta* species are:
(a) Partial stem parasite (b) Root parasite
(c) Total stem parasite (d) Epiphytes

71. Hypogeal germination is found in:
(a) *Cucurbita* (b) Maize
(c) *Rhizophora* (d) Bean

72. *Balanophora* species are:
(a) Partial stem parasite (b) Total stem parasite
(c) Total root parasite (d) Partial root parasite

73. Which one is the non-endospermic seed?
(a) Maize (b) Pea
(c) Wheat (d) Rice

74. Pneumatophores are helpful in:
(a) Transpiration (b) Carbohydrate metabolism
(c) Protein synthesis (d) Respiration

75. Black pepper is a:
(a) Tree (b) Shrub
(c) Climber (d) 3 cm tall herb

76. Three types of flowers are usually found in:
(a) Verticillaster (b) Cyathium
(c) Capitulum (d) Hypanthodium

77. The edible part of potato is:
(a) Root (b) Bud
(c) Fruit (d) Stem

78. The plant with biggest flower is:
(a) Partial root parasite (b) Partial stem parasite
(c) Total root parasite (d) Total stem parasite

79. Presence of which of the following is associated with seed dormancy?
(a) Starch (b) Ethylene
(c) IAA (d) Abscisic acid

*80. The phenomenon of germination of seeds inside the fruit itself is: **(CBSE 1992)**
(a) Ovipary (b) Vivipary
(c) Hypogeal germination (d) None of these

81. In which of the following plants vegetative reproduction takes place with the help of bulbils? **(BHU 1990)**
(a) *Pistia* (b) *Colocasia*
(c) *Zingiber* (d) *Agave*

82. A modification of a bud that can bear leaves, flowers and fruits and may also become branched is called:
(a) Prickle (b) Spine
(c) Thorn (d) Trichome

83. Velamen tissue is found in: **(CBSE 1991)**
(a) Aerial roots of orchids only
(b) Roots of Screwpine
(c) Leaves of *Ficus elastica*
(d) Aerial and terrestrial roots of orchids

84. Capitulum inflorescence is seen in:
(a) Cruciferae (b) Liliaceae
(c) Compositae (d) Solanaceae

85. Which is not a root? **(CPMT 1993)**
(a) Potato (b) Carrot
(c) Sweet potato (d) Radish

86. Vivipary is a characteristic of: **(CPMT 1994)**
(a) Hydrophytes (b) Xerophytes
(c) Mesophytes (d) Mangroves

87. Tap roots are commonly found in:
(a) Gymnosperms (b) Angiosperms
(c) Dicots (d) Monocots

88. Which of the following plants has parallel venation in its leaves?
(a) Castor (b) Grass
(c) Moss (d) Fern

89. *Muehlenbeckia* (cocoloba) is a good example of:
(a) Phylloclade (b) Phyllode
(c) Rhizome (d) Corm

90. *Bignonia* is the best example of:
(a) Hook climber (b) Twiner
(c) Tendril climber (d) Thorn climber

91. Leafless stem of onion which is produced to bear flowers is called:
(a) Scape (b) Rachis
(c) Penduncle (d) Floral axis

92. *Pisum sativum* is:
(a) A tree (b) A heterotroph
(c) An autotroph (d) A shrub

93. In which of the following plants does the stem perform the function of storage and perennation? (AFMC 1994)
(a) Radish (b) Wheat
(c) Ginger (d) Groundnut

94. Respiratory roots are found in:
(a) Betel (b) Chestnut
(c) *Jussiaea* (d) *Zea*

95. Reserved food material is mainly found in:
(a) *Coccinia* (b) *Cucurbita*
(c) *Hibiscus* (d) Potato

96. Bipinnate leaf is characteristic of:
(a) Papilionaceae (b) Ranunculaceae
(c) Mimosoideae (d) None of these

97. In which of the following does the germination of embryo occur when the fruit is still attached to the plant?
(a) Mangrove plants (b) Pine apple
(c) *Rhizobium* (d) *Rhizocolonium*

98. Most plants in tropical countries bear:
(a) Winter buds (b) Summer buds
(c) Monsoon buds (d) Naked buds

*99. Food stored in bulb is within:
(a) Inflorescence (b) Enlarged leaf base
(c) Swollen stem (d) Enlarged roots

100. Velamen the spongy tissue is present in:
(a) Breathing roots (b) Parasitic roots
(c) Tuberous roots (d) Epiphytic roots

101. Zig-zag cyme is an important characteristic of:
(a) Papilionatae (b) Mimosoideae
(c) Solanaceae (d) Cruciferae

102. Which of the following is essential for seed germination? (CBSE 1991)
(a) Light (b) Minerals
(c) High temperature (d) Water

103. Edible part of sweet potato is a modification of:
(a) Tap root (b) Adventitious root
(c) Stem (d) Underground branch

104. A plant bears fruit, has a column of vascular tissue and a tap root system. This plant is a: (CBSE 1994)
(a) Angiosperm and dicot
(b) Gymnosperm and monocot
(c) Angiosperm and monocot
(d) Gymnosperm and dicot

105. Green photosynthetic roots occur in: (AFMC 1991)
(a) *Cuscuta* (b) *Portulaca*
(c) *Tinospora* (d) *Pandanus*

106. Roots are modified into thorny branches in: (BHU 1989)
(a) *Acanthorhiza* (b) *Asparagus*
(c) *Vanilla* (d) *Dioscorea*

107. Hypogeal germination of albuminous seed is seen in: (BHU 1992)
(a) Maize (b) Castor
(c) Gram (d) Bean

108. Inflorescence of banana is:
(a) Raceme (b) Spike
(c) Spadix (d) Catkin

109. If soaked pea seeds are kept in three separate flasks, they would germinate best in flask containing:
(a) Oxygen (b) Carbon dioxide
(c) Nitrogen (d) Water

110. In *Agave* vegetative reproduction is carried out through: (CBSE 1991)
(a) Bulbils (b) Rhizome
(c) Stolon (d) Sucker

111. The way in which a leaf is rolled or folded in bud condition is called:
(a) Vernation (b) Ptyxis
(c) Venation (d) Phyllotaxy

112. One of the following is expected to have an age of 1500 years: (BHU 1990)
(a) *Cycas* (b) *Sequoia*
(c) *Pinus* (d) *Eucalyptus*

113. Roots which help the horizontal branches of banyan tree in the air are called: (MDAT Bihar 1991)
(a) Stilt roots (b) Thumb roots
(c) Prop roots (d) All of these

114. When the petiole is modified into a leafy green structure, this structure is known as:
(a) Cladode (b) Phyllode
(c) Phylloclade (d) True leaf

115. In a raceme the flowers are:
(a) Of separate sexes
(b) Of the same sex
(c) Arranged in basipetal succession
(d) Arranged in acropetal succession

116. Phylloclade is a modification of: (CET J&K 2002)
(a) Root (b) Stem
(c) Leaf (d) None of these

117. The plant that stores food reserves in leaves:
(a) Mango (b) Sweet potato
(c) Onion (d) Sugar cane

118. In *Amorphophallus* vegetative reproduction is carried out through:
(a) Bulbs (b) Offset
(c) Corm (d) Rhizome

119. Carrot is a:
(a) Root (b) Stem
(c) Flower (d) Inflorescence

120. The stipules are modified into tendrils in: (CPMT 1991; St. Jones 2002)
(a) *Smilax* (b) *Asphodelus*
(c) *Gloriosa* (d) *Asparagus*

121. Seeds of orchid are:
(a) Light and dry (b) Small and stricky
(c) Large and heavy (d) Dry and heavy

122. Among the following finely dissected leaves are common in: (Re. Ex. CPMT 1991)
(a) Submerged plants (b) Free floating plants
(c) Emerged plants (d) Rooted floating plants

123. Where would you look for active cell division in a plant?
(a) In pith cells
(b) In the cells of cortex
(c) In the internodal region
(d) All the tips of stem and roots

124. In onion the inflorescence is: (AFMC 1991)
(a) Umbel (b) Catkin
(c) Raceme (d) Corymb

125. Ginger is a stem and not a root because: (BCECE 2002)
(a) It lacks chlorophyll
(b) It has nodes and internodes
(c) It is bitter in taste
(d) It stores food

126. Main photosynthetic organs of *Lathyrus sativus* plants are:
(a) Leaves (b) Leaflets
(c) Stipules (d) Phyllodes

127. Caryopsis fruit is found in:
(a) Tomato (b) Maize (or Gramineae)
(c) Brinjal (d) Coconut

128. An erect unbranched stem with hollow internodes as found in bamboo is called:
(a) Caudex (b) Culm
(c) Scape (d) Phylloclade

129. Dispersal of seeds by mechanical explosion of fruits is common among: (AMU 1990)
(a) Paddy and cucurbits (b) Grasses and chillies
(c) Legumes (d) Sunflower family

130. Among the following which one is not a modification of stem? (AFMC 1990)
(a) Ginger (b) Mango ginger
(c) Tuber (d) Garlic

131. The inflorescence of wheat is:
(a) Spikelet (b) Spike of spikelets
(c) Panicle of spikelets (d) Spike

132. Compound umbels are seen in:
(a) *Foeniculum* (b) *Coriandrum*
(c) *Daucus carota* (d) All of these

133. Leaves fall off from branches in winter on account of:
(a) Shortening of day time
(b) Formation of abcission layer
(c) Fall in atmospheric temperature
(d) Fall in atmospheric pressure

*134. Some plants have roots and rhizome both underground structures, which characteristic of rhizome would distinguish them from roots?
(a) Rhizome are thinner than roots
(b) Rhizome are darker in colour than roots
(c) Rhizome have scale leaves with buds in the axils
(d) Rhizome are thicker than roots

135. Scutellum is a/an:
(a) Protective covering of radicle
(b) Protective covering of plumule
(c) Endosperm of gymnosperms
(d) Shield-shaped cotyledon

136. Which of the following is the insectivorous plants?
(a) *Drosera* (b) *Ranunculus*
(c) *Hydrilla* (d) Castor

137. Partial parasite is one which:
(a) Takes only water from host
(b) Takes both water and minerals from host but manufactures its own food
(c) Draws food from host only at times
(d) Uses the host-just as support

138. An inflorescence in which two lateral branches develop on either side of a terminal flower which again branch in a similar fashion to:
(a) Racemose raceme (b) Helicoid cyme
(c) Dichasial cyme (d) Umbel

139. The edible part of sweet potato is:
(a) Underground stem
(b) Leaves
(c) Stem
(d) Adventitious tuberous roots

140. Plants identical to mother plants can be had from:
(a) Stem cutting (b) Seeds
(c) Both (a) and (b) (d) None of these

141. Branches of stem are:
(a) Endogenous in origin
(b) Superficial
(c) Exogenous in origin
(d) Partly endogenous and partly exogenous

142. Longest plants of world belong to:
(a) Dicots (b) Monocots
(c) Gymnosperms (d) Pteridophytes

143. Which is not a modification of stem?
(a) Corm of *colocasia* (b) Rhizome of ginger
(c) Pitcher of *Nepenthes* (d) Tuber of potato

144. Thorns, spines, prickles in plant work as:
(a) Organs of offence (b) Respiratory organs
(c) Defensive organs (d) Excretory organs

145. Plants manufacturing their own food are called:
(a) Epiphytes (b) Parasites
(c) Saprophytes (d) Autotrophic

146. Inflorescence of *Ficus* is called:
(a) Hypanthodium (b) Cyathium
(c) Verticillaster (d) Spadix

147. Potatoes are borne on:
(a) Adventitious roots (b) Lateral roots
(c) Primary roots (d) Stolons

148. Saprophytes:
(a) Can absorb complex food direct from non-living matter
(b) Cannot synthesize any complex food

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(c) Cannot synthesize their own protoplasm
(d) Need help of enzymes for absorption

*149. Bulb of garlic and onion have:
(a) Greatly developed root system
(b) No leaves
(c) No stem
(d) Greatly reduced stems

150. Vivipary in plants is the character of: (CBSE 1990; BHU 1993)
(a) Xerophytes (b) Hydrophytes
(c) Halophytes (d) Hygrophytes

151. A fibrous root system is adapted better than tap root system to perform the function of: (BHU 1993)
(a) Absorption of water and minerals
(b) Transport of water and organic food
(c) Anchorage of plants into the soil
(d) Storage of food

152. When dichasial cyme ends into monochasial cyme, the inflorescence is:
(a) Uniparous cyme (b) Verticillaster
(b) Biparous cyme (d) Cincinnus

153. What is the arrangement of flower in *Brassica* and *Pisum*?
(a) Basipetal (b) Acropetal
(c) Both (a) and (b) (d) Centrifugal

154. Banana plant develops from: (CBSE 1990)
(a) Rhizome (b) Seed
(c) Sucker (d) Stolon

*155. The presence of sheathing leaf base and a ligule is characteristic of: (BHU 1992; CET Chandigarh 1997)
(a) Fern leaf (b) Banana leaf
(c) Cycas leaf (d) Grass leaf

156. The main difference between biennials and perennials is that the perennials: (CBSE 1994)
(a) Invariably show asexual reproductive structures
(b) Do not die after seasonal production of fruits
(c) Always have underground perennating structures
(d) Are trees species

157. *Ipomoea batatus* is a: (CET J&K 2002)
(a) Underground root (b) Tuber
(c) Rhizome (d) Corm

158. The plant whose seeds are known to have the longest viability period is:
(a) *Carica papaya* (papaya)
(b) *Nelumbo nucifera* (lotus)
(c) *Zizyphus mauritiana* (ber)
(d) *Triticum vulgare* (wheat)

159. A biennial is:
(a) A plant which flowers every year and completes its life cycle in two years
(b) A plant which completes its life in two years
(c) A plant which flowers every two years
(d) None of the above

*160. Sessile flowers of only one sex are found in the inflorescence are called: (MDAT Bihar 1990)
(a) Spadix (b) Catkin
(c) Achene (d) Panicle

161. *Santalum album* is normally considered as:
(a) Partial stem parasite (b) Complete stem parasite
(c) Complete root parasite (d) Partial root parasite

162. Tendrillar stipules are found in:
(a) *Smilax* (b) *Dolichos lablab*
(c) *Acacia* (d) *Artocarpus*

163. Root hairs occur in the:
(a) Root cap (b) Region of cell elongation
(c) Apical meristem (d) Region of maturation

164. Root develops from:
(a) Plumule (b) Radicle
(c) Stem (d) Leaf

165. Velamen is a specialized tissue found in:
(a) Parasites
(b) Halophytes
(c) Aerial roots of some orchids
(d) All epiphytes

166. Corm is:
(a) A horizontal underground fused stem
(b) An underground vertical stem
(c) An underground root
(d) An underground stem

167. Cyathium and hypanthodium inflorescence resemble each other in possessing: (BHU 1990)
(a) Unisexual flowers (b) Apical pore
(c) Petaloid bracts (d) Nectar glands

168. When the inflorescence axis is branched it is called:
(a) Head (b) Panicle
(c) Cymose (d) Umbel

169. Angiosperms differ from gymnosperms in having:
(a) Broad leaves (b) Tracheids
(c) Fruits (d) Cotyledons

170. Plants which obtain their food from other living organisms by haustoria are:
(a) Saprophytes (b) Parasites
(c) Symbionts (d) Hydrophytes

171. Which is an example of tuberous root?
(a) *Calocasia antiquorum* (b) *Ipomaea batatas*
(c) *Ficus benghalensis* (d) *Solanum tuberosum*

172. The primary function of stem is:
(a) To bear and hold out the leaves
(b) To help vegetative propagation
(c) To anchor the plants in soil
(d) To absorb water and minerals

173. Haustoria or sucking roots are found in:
(a) *Tinospora* (b) *Cuscuta*
(c) Betel (d) Orchids

174. If seed is defined as an ovule modified as a result of fertilization, one may expect to find seed in:
(a) Gymnosperms only (b) Angiosperms only
(c) All vascular plants (d) Phanerogams

175. Function of stem is:
(a) Storage
(b) To produce branches and leaves

(c) Conduction
(d) All of these

176. Cyathium inflorescence is the characteristic of family:
(a) Compositae (b) Euphorbiaceae
(c) Cruciferеae (d) Solanaceae

177. Buds are typically found:
(a) At the apex or axil of leaves
(b) At the tips of the branches
(c) At the base of the leaves only
(d) Both at the tip of branches and at leaf base

178. A unipinnate compound leaf looks very much like an ordinary branch with simple leaves. It can be differentiated from the branch in the following way:
(a) The leaflet of the compound leaf has no veins
(b) The branch has axillary buds in the axil of the leaves
(c) The compound leaf has a terminal bud
(d) None of the above

179. Nodules with nitrogen fixing bacteria are present in:
(a) Wheat (b) Cotton
(c) Gram (d) Mustard

180. *Dendrophthoe* or *Viscum* is a:
(a) Partial stem parasite (b) Total root parasite
(c) Total stem parasite (d) Partial root parasite

181. Which of the following is the rootless aquatic herb in which a portion of leaf forms a small bladder that traps water insects?
(a) *Drosera* (b) *Dionaea*
(c) *Utricularia* (d) *Nepenthes*

182. Prop roots are:
(a) Tap roots (b) Fasciculated roots
(c) Branched roots (d) Adventitious roots

183. Food stored in aroids is within:
(a) Enlarged roots (b) Inflorescence
(c) Swollen stem (d) Swollen leaf bases

184. Vivipary in plants means:
(a) Development of fruit after the fertilized seed is burried in the soil
(b) Germination of seeds in crevices of the stem where some soil is deposited
(c) Germination of seeds while inside the fruit when it is still on parent tree
(d) Organization of several shoots

185. Each spikelet bears a central stalk called:
(a) Rachis (b) Rachilla
(c) Peduncle (d) Pedicel

186. On the margins of leaves of a plant called *Bryophyllum*, tiny plants grow complete with roots. These tiny plants fall off and continue to grow. This is a form of:
(a) Sexual reproduction
(b) Reproduction by fission
(c) Vegetative reproduction
(d) Hermaphroditism

187. Removal of apical bud during flowering results in: **(CPMT 1993)**
(a) Death of the plant
(b) Formation of new apical bud
(c) Promotion of lateral branching
(d) Elongation of main stem

188. The distinguishing character of imparipinnate leaf is that: **(Re. Ex. CPMT 1991)**
(a) Rachis is strong
(b) Leaflets are large
(c) Rachis is terminated by an unpaired odd leaflet
(d) All leaflets are borne in pairs

189. Lateral root branches normally arise from parents roots by formation of root primordia by divisions in:
(a) Pericycle cells lying in area between two cell protoxylem points
(b) The cells of endodermis
(c) Pith cells between the vascular bundles
(d) Inter fascicular parenchyma

190. Vegetative growth of potato is by: **(BHU 1991)**
(a) Rhizome (b) Tuber
(c) Sucker (d) Bulb

191. Lateral roots in angiosperms originate most commonly in the:
(a) Endodermis (b) Pericycle
(c) Cortex (d) Epidermis

192. *Artabotrys* is a hook climber in which the hooks are modified: **(BHU 1990)**
(a) Inflorescence axis (b) Petioles
(c) Roots (d) Stipules

193. Which of the following parasite is exclusively epiphytic?
(a) *Balanophora* (b) *Orobanche*
(c) *Cuscuta* (d) *Loranthus*

194. The prop roots of banyan tree are meant for:
(a) Providing support to the big size of the tree
(b) The retention of water in soil
(c) Absorption of water soil
(d) Absorption of air from atmosphere

195. The stem is extremely enlarged in:
(a) Tuber (b) Corm
(c) Bulb (d) Rhizome

196. The inflorescence in Cruciferae is:
(a) Raceme (b) Catkin
(c) Spadix (d) Head

197. All monocotyledons show:
(a) Epigeal germination (b) Viviparous germination
(c) Hypogeal germination (d) None of these

198. Roots that develop from any part of the plant except the radicle are called as: **(AFMC 1994)**
(a) Fibrous roots (b) Adventitious roots
(c) Stilt roots (d) Tap roots

199. Adnate stipules are found in:
(a) China rose (b) Cotton
(c) Rose (d) *Gardenia*
(e) *Polygonum* (f) *Smilax*

200. Accessory buds develop:
(a) At the apex of the branch
(b) By the side of axillary bud
(c) At the apex of the stem
(d) In the axil of a leaf

201. A leaf without petiole is called:
(a) Petiolate (b) Sessile
(c) Subsessile (d) Subpetiolate

202. Which is not a modification of stem?
(a) Tuber of Potato (b) Pitcher of *Nepenthes*
(c) Corm of *Colocasia* (d) Rhizome of ginger

203. When a large number of sessile flowers grow from a suppressed rachis giving rise to globose structure, the inflorescence is called: **(Re. Ex. CPMT 1991)**
(a) Catkin (b) Capitate
(c) Umbel (d) Corymb

204. Inflorescence with flattened floral axis in the form of receptacle having a whorl of involucral bracts surrounding it is known as:
(a) Head (b) Umbel
(c) Corymb (d) Raceme

***205.** A plant that is all root and root performs the function of assimilation and reproduction is:
(a) *Utricularia* (b) *Balanophora*
(c) *Podostemon* (d) None of these

206. Angiospermic plant lacking roots is:
(a) *Utricularia* (b) *Ceratophyllum*
(c) *Balanophora* (d) All of these

207. Multiple root cap is present in:
(a) *Pandanus* (b) *Eichhornia*
(c) *Pistia* (d) *Lemna*

208. Thorns, spines, prickles in plants work as:
(a) Respiratory organs (b) Excretory organs
(c) Defensive organs (d) None of these

209. Leaves adapt themselves to their living environment. Which statement concerning their reaction to habitat is true?
(a) Leaves of aquatic plants have large air spaces
(b) Leaves of shaddy plants are large and thin
(c) The leaves which are submerged in water have multiple layer of epidermis
(d) None of the above

210. The stem of pea climbs up with the help of: **(Raj. PMT 2002)**
(a) Leaflet tendrils (b) Stipular tendrils
(c) Leaf tendrils (d) None of these

211. Plants in which root arises from the base of the stem are:
(a) Maize (b) Wheat
(c) Rice (d) Onion
(e) All of these

212. Heterophylly is found in:
(a) Submerged hydrophytes
(b) Free floating hydrophytes
(c) Emerged hydrophytes
(d) Rooted and floating hydrophytes

213. The fleshy, swollen roots of *Brassica rapa* and *Chenopodium album* are termed as:
(a) Fusiform (b) Conical
(c) Nodulated (d) Napiform

214. The thick roots arising from the apical portion of the underground stems are known as:
(a) Assimilatory roots (b) Clinging roots
(c) Contractile roots (d) None of these

215. The mode of arrangement of leaves on the stem and the branch is known as:
(a) Vernalization (b) Vernation
(c) Venation (d) Phyllotaxy

216. Which inflorescence belongs to Compositae? **(CPMT 1993)**
(a) Spadix (b) Umbel
(c) Catkin (d) Capitulum

217. Insectivorous plants kill insects because: **(Pb. PMT 1997)**
(a) Insects eat away their leaves
(b) Insects eat away their fruits
(c) They are heterotrophic of consumer trophic level
(d) They fulfil their requirement of nitrogen from killed insects

218. A family whose name is based upon its inflorescence is:
(a) Euphorbiaceae (b) Asteraceae
(c) Fabaceae (d) Malvaceae

219. Stilt roots are reported from: **(MDAT Bihar 1994; BHU 1996)**
(a) *Padanus* (b) *Raphanus sativus*
(c) *Mangifera indica* (d) *Bryophyllum*

220. A plant that grows in nitrogen deficient soil is:
(a) Wheat (b) Maize
(c) *Drosera* (d) *Bambusa*

221. The erect stem of *Pinus* is:
(a) Deliquescent (b) Caudex
(c) Culm (d) Excurrent

***222.** Largest and edible bud is of: **(CET Karnataka 1991)**
(a) Cabbage (b) Cauliflower
(c) Onion (d) *Agave*

223. Nepenthes is:
(a) Symbiont (b) Partial parasite
(c) Saprophytic (d) Insectivorous

224. Which of the following is prickle climber?
(a) Rose (b) *Calamus*
(c) Both (a) and (b) (d) None of these

225. Large woody climbers are:
(a) Trailers (b) Twinners
(c) Climbers (d) Lianas

226. Banana plant develops from: **(CBSE 1990)**
(a) Rhizome (b) Seed
(c) Sucker (d) Stolon

227. A plant that trails prostrately on ground is:
(a) *Smilax* (b) *Portulaca*
(c) *Pothos* (d) None of these

228. Botanical name of Venus fly trap is:
(a) *Aldovanda* (b) *Utricularia*
(c) *Nepenthes* (d) *Dionaea*

229. Tuberous root is present in:
(a) *Solanum tuberosum* (b) *Ficus benghalensis*
(c) *Mirabilis jalapa* (d) None of these

230. Rhizome is: (AFMC 1992)
(a) Geotropic (b) Diageotropic
(c) Plageotropic (d) –ve geotropic

231. A plant living symbiotically inside another plant is: (AFMC 1994)
(a) Saprophyte (b) Endophyte
(c) Semiparasite (d) Parasite

232. Which of the following is a lianas?
(a) *Hiptage* (b) *Gnetum*
(c) *Bauhinia vauhili* (d) All of these

233. Imparipinnate leaf is the one where: (CPMT 1991)
(a) Leaflets are borne in pairs
(b) Leaflets are small
(c) Leaflets are large
(d) Rachis is terminated by an odd leaflet

234. A big weak creeping stem rooting at nodes is called:
(a) Trailer (b) Stolon
(c) Runner (d) Offset

235. An insectivorous plant having glandular structures on its leaf secreting sticky fluid is: (AIIMS 1991)
(a) Venus fly trap (b) Sundew plant
(c) Butterwort (d) Aldovanda

236. Buds developing from any other part of the plant instead of terminal or lateral part is known as:
(a) Accessory buds (b) Floral buds
(c) Adventitious buds (d) Apical buds

237. The main difference between thorns and prickles is in having:
(a) Endogenous origin (b) Vascular supply
(c) Bark (d) All of these

238. A thick vertical underground stem having more diameter than length is:
(a) Sucker (b) Tunicated bulb
(c) Corm (d) None of these

239. Cone like shape of the plant because of the growth of main axis as well as lateral branches is observed in:
(a) *Cocos* (b) *Pinus*
(c) *Casuarina* (d) Both (b) and (c)

240. In *Ruscus* the green leaf like structure bearing a floral bud is:
(a) Cladode (b) Phylloclade
(c) Phyllode (d) Leaf

241. Stem is specialized to perennate and store food in: (AFMC 1994)
(a) Groundnut (b) Ginger
(c) Beet (d) Sugar cane

242. Which is not a stem modification? (AFMC 1990)
(a) Ginger (b) Mango
(c) Potato (d) Garlic

243. Usually the rhizomes are horizontal but may be vertical in:
(a) Lotus (b) Turmeric
(c) Sugar cane (d) Ginger

244. Plant having column of vascular tissues bearing fruits and having a tap root system is: (CBSE 1994)
(a) Monocot
(b) Dicot
(c) Gymnosperm or dicot
(d) Gymnosperm or monocot

245. Roots that hold horizontal branches of banyan tree in the air are: (MDAT Bihar 1991; MPPMT 1993)
(a) Thumb roots (b) Prop roots
(c) Stilt roots (d) All of these

246. In which plant, the leaves are modified into roots?
(a) *Salvinia* (b) *Pistia*
(c) *Eichhornia* (d) *Fragaria*

247. Distinguishing character of imparipinnate leaf is that: (Re. Ex. CPMT 1992)
(a) Leaflets are large
(b) Rachis is terminated by an unpaired leaflet
(c) Rachis is strong
(d) All leaflets are borne in pairs

248. When the stipules fall off before the unfolding of leaf, they are called:
(a) Caducous (b) Deciduous
(c) Persistent (d) None of these

249. Spiny margins occur in the leaves of:
(a) *Papaver* (b) *Parkinsonia*
(c) *Argemone* (d) *Opuntia*

250. Entire leaf is modified into leaf tendrils in:
(a) *Lathyrus odoratus* (Sweet pea)
(b) *Lathyrus aphaca* (Wildpea)
(c) *Gloriosa*
(d) *Clematis*

251. Corm is an: (AFMC 1996)
(a) Underground vertical leaf
(b) Underground swollen stem
(c) Underground horizontal root
(d) Underground horizontal leaf

252. The weak stem of *Piper betle* (Pan) clings to the support by:
(a) Hook climbers (b) Thorn climbers
(c) Tendril climbers (d) Root climbers

253. If cotyledons are brought above the soil, the germination is:
(a) Hypogeal (b) Epigeal
(c) Vivipary (d) None of these

254. A shorter and thicker subaerial weak stem bearing a cluster of leaves and giving out adventitious roots from all nodes is:
(a) Stolon (b) Runner
(c) Sucker (d) Offset

*255. The tegmen of seed develops from: (BHU 1990)
(a) Perisperm (b) Funicle
(c) Inner integument (d) Outer integument

256. In some plants, *e.g.*, *Barberris*, *Opuntia*, etc., to check the transpiration, whole leaf or its parts are modified into:
(a) Leaf hooks (b) Leaf scales
(c) Leaf spines (d) Leaf tendrils

257. Vivipary is the characteristic feature of: **(BHU 1990)**
(a) Hydrophytes (b) Xerophytes
(c) Halophytes (d) Mesophytes

258. Phyllotaxy is: **(AIIMS 1996)**
(a) Mode of leaf arrangement on stem
(b) Types of roots
(c) Type of ovary
(d) Arrangement of sepals and petals in a flower

259. The largest leaf belongs to: **(CPMT 1995)**
(a) *Nerium* (b) Tobacco
(c) *Victoria* (d) *Rafflesia*

260. In cotton and papaya, the seed germination is of type:
(a) Hypogeal in both
(b) Hypogeal and epigeal respectively
(c) Epigeal in both
(d) Epigeal and Hypogeal respectively

*261. The first few leaves after the cotyledons in the seedling of *Acacia* are pinnately compound but the petioles of the upper compound leaves are flattened and they bear few pinnae. The adult plant has only parallel veined leaf like flattened petioles but without any pinnae. These observation lead us to the conclusion that:
(a) The leaves in the adult plant are reduced to phyllode while the seedling leaves are unreduced
(b) The green parallel veined structures in the adult plant are phylloclades
(c) The plant exhibits heterophylly bearing simple leaves in the adult plant and compound leaves in the seedling
(d) The adult plant leaves are a case of reversion where they become simple like cotyledons

262. If a leaf segment of *Bryophyllum* is planted in the soil, it produces new plants. This is because its leaf has :
(a) Higher concentrations of auxins
(b) Higher concentrations of cytokinins
(c) Small embryos
(d) Buds

263. Lamina having large terminal lobe and a smaller lower lobe is called:
(a) Cordate (b) Saggitate
(c) Ovate (d) Lyrate

264. Two chief functions of leaves are:
(a) Transpiration and respiration
(b) Respiration and digestion
(c) Photosynthesis and respiration
(d) Photosynthesis and transpiration

265. In *Ficus*, bud scales are modified:
(a) Leaves (b) Stipules
(c) Stem (d) Roots

266. In some plants, *e.g.*, *Cassia obtusifolia*, the lamina having rounded or blunt apex with a short point in the middle is:
(a) Obtuse (b) Retuse
(c) Emarginate (d) Mucronate

267. 'Sword suckers' are developed in:
(a) *Musa* (b) *Smilax*
(c) *Cocos* (d) *Chrysanthemum*

268. In humid climate, presence of spines in shrubs is: **(Re. Ex. CPMT 1992)**
(a) To defend against mammal herbivory
(b) To defend against woodcutters
(c) To reduce transpiration
(d) To check seed predation by birds

269. Vegetative reproduction by layering is found in: **(AFMC 1996)**
(a) Jasmine (b) Mango
(c) Rose (d) All of these

270. A monocot showing reticulate venation is: **(APMEE 1995)**
(a) *Zea* (b) Plum
(c) Bambusa (d) *Smilax*

271. A fibrous root system is better adapted than tap root system for: **(BHU 1993)**
(a) Storage of food
(b) Anchorage of plant to soil
(c) Absorption of water and minerals
(d) Transport of water and organic food

272. When the stem is modified into a green flattened structure, it is called: **(AFMC 1996)**
(a) Bulbil (b) Tendril
(c) Phyllode (d) Phylloclade

*273. Leaves are changed into spine in xerophytic structures called: **(CPMT 1996)**
(a) Phyllode (b) Cladode
(c) Phylloclade (d) All of these

274. The tendrils of pea plants are modified: **(BHU 1997)**
(a) Stipules (b) Axillary buds
(c) Aerial roots (d) Terminal leaflets

275. A plant that trails horizontally is called:
(a) Lianas (b) Procumbent
(c) Decumbent (d) None of these

276. Haustoria or sucking roots occur in: **(BHU 1996)**
(a) Betel (b) Orchids
(c) *Cuscuta* (d) *Tinospora*

277. In *Tamarind* (imli) the pinnate leaf is: **(DPMT 1994)**
(a) Tripinnate (b) Bipinnate
(c) Paripinnate (d) Imparipinnate

278. In *Calotropis* the arrangement of leaves is:
(a) Alternate (b) Opposite decussate
(c) Opposite superimposed (d) Whorled

279. Parasitic plants obtain nourishment through: **(CPMT 1995)**
(a) Roots (b) Haustoria
(c) Thorns (d) Pores

280. Aerial absorptive roots occur in: **(JEE Orissa 1995)**
(a) Epiphytes (b) Mesophytes
(c) Hydrophytes (d) Xerophytes

281. Approximately diameter of *Victoria* leaf is: **(BHU 1996)**
(a) 1 m (b) 1.3 m
(c) 2 m (d) 3 m

282. Climbing roots occur in: **(APMEE 1996)**
(a) *Vanilla* (b) *Vanda*
(c) *Pongamia* (d) *Taeniophyllum*

283. Which is not a characteristic feature of the stem?
(a) Arises from plumule and is ascending
(b) Growing apex is having a bud
(c) Hairs are multicellular
(d) Branches arise endogenously

284. The unbranched, cylindrical, strong stem of *Cocos nucifera* (cocos) is known as:
(a) Culm (b) Caudex
(c) Excurrent stem (d) None of these

285. Swollen spongy petiole is present in: **(APMEE 1996)**
(a) *Hydrilla* (b) *Eichhornia*
(c) *Rubia* (d) *Pistia*

286. Spike with unisexual flower is found in: **(AFMC 1996)**
(a) Wheat (b) Mulberry
(c) Grasses (d) Mango

287. Roots developing from plant parts other than radicle are: **(AFMC 1995)**
(a) Epiphyllous (b) Epicaulous
(c) Adventitious (d) Fibrous

*288. Beauty of flower *Bougainvillea* is due to:
(a) Bract (b) Calyx
(c) Corolla (d) Androecium

289. Petiole modified into tendril is found in: **(AFMC 1996)**
(a) *Clematis* (b) *Passiflora*
(c) *Trapa* (d) *Cuscuta*

290. A plant belonging to Liliaceae with stipules modified into tendrils is: **(Pondicherry 1996)**
(a) *Asparagus* (b) *Asphodelus*
(c) *Gloriosa* (d) *Smilax*

291. The stem of *Bambusa* (Bans) is of which type?
(a) Culm (b) Excurrent
(c) Caudex (d) Deliquescent

292. Insectivorous plant with rosette of spiny, margined, bilobed, hinged and winged leaves for catching the prey is:
(a) *Nepenthes* (b) *Drosera*
(c) *Dionaea* (d) *Utricularia*

293. Fusiform roots are found in: **(BHU 1996)**
(a) *Solanum tuberosum* (b) *Colocasia*
(c) *Daucus carota* (d) *Raphanus sativus*

294. In which of the following plants the leaf apex modifies to form a tendril? **(AFMC 2002)**
(a) *Gloriosa* (b) *Clematis*
(c) *Smilax* (d) *Lathyrus*

295. Insectivorous plants catch insects for obtaining: **(CPMT 1996)**
(a) Na—K (b) Taste
(c) Phosphorus (d) Nitrogen

296. When the stem is modified into a green flattened structure it is called: **(AFMC 1996)**
(a) Bulbil (b) Tendril
(c) Phyllode (d) Phylloclade

297. A weak stemmed plant in which three terminal leaflets are modified to form hooks is:
(a) *Bignonia* (b) *Vitis*
(c) *Passiflora* (d) *Duranta*

298. In some plants, *e.g.*, *Asparagus*, *Ruscus*, etc., to prevent transpiration and to protect buds, the leaves are reduced into:
(a) Leaf tendrils (b) Leaf spines
(c) Leaf scales (d) Leaf hooks

299. Vivipary in plant means:
(a) Germination of seeds in the crevices of stem where some soil is deposited
(b) Development of peanut fruits after the fertilization
(c) Organization of several shoots
(d) Germination of seeds inside the fruit while it is still on the parent tree

300. Stipular tendril is found in: **(CPMT 1997)**
(a) *Smilax* (b) *Gloriosa*
(c) *Antigonon* (d) *Passiflora*

301. Rachis is present in:
(a) Compound leaf
(b) Pinnately compound leaf
(c) Palmately compound leaf
(d) Simple leaf

302. Adventitious roots: **(AFMC 1994; CET Chandigarh 1997)**
(a) Develop from radicle
(b) Develop from any part of the plant body except the radicle
(c) Develop from flowers
(d) Develop from embryo

303. In *Lathyrus aphaca* the leaves are modified into: **(AIIMS 1997)**
(a) Tendril (b) Scale
(c) Stem (d) Spine

304. Smallest dicotyledonous parasitic plant of the world is: **(Pondicherry 1997)**
(a) *Primula minutissima*
(b) *Corydalis nana*
(c) *Arceuthobium minustissiumum*
(d) *Marsilea minuta*

305. Floral axis is modified into tendril or floral bud tendrils are found in: **(Pondicherry 1997; BHU 1997)**
(a) *Antigonon* (b) *Lathyrus*
(c) *Pisum* (d) *Passiflora*

306. Among the following which one is not an insectivorous plant? **(CET Chandigarh 1997)**
(a) *Dionaea* (b) *Drosera*
(c) *Dischidia* (d) *Pinguicula*

*307. The arrangement of leaves in a bud with respect to each other is called: **(DPMT 1997)**
(a) Vernation (b) Venation
(c) Phyllotaxy (d) Ptyxis

308. Which one of the following is not a rhizome? **(Pb. PMT 1997)**
(a) Lotus (b) Ginger
(c) Turmeric (d) *Colocasia*

309. *Utricularia* has: **(CPMT 1998)**
(a) Pitcher (b) Bladders
(c) Spoon (d) Hairs

310. The floating roots are the characteristic feature of: **(BHU 2000)**
(a) *Jussiaea* (b) *Viscum*
(c) *Tinospora* (d) *Vanda*

311. Root cap is absent in: **(BHU 2000)**
(a) Lithophytes (b) Xerophytes
(c) Hydrophytes (d) Mesophytes

*312. In a single seeded fruit, single seed develops due to presence of: **(CPMT 2001)**
(a) One carpel (b) One placenta in ovary
(c) Unilocular ovary (d) Single ovule in ovary

*313. Cotyledons store food in all of the following except: **(Manipal 2001)**
(a) Beans (b) Pea
(c) Mustard (d) Castor

314. What is the eye of potato? **(CBSE 2001)**
(a) Axillary bud (b) Accessory bud
(c) Adventitious bud (d) Apical bud

*315. Which is the odd type of vegetable in a basket containing the following? **(CET Karnataka 2002)**
(a) Potatoes (b) Beet roots
(c) Radishes (d) Carrots

316. Which one of the following has thorns, bearing leaves and flowers on them? **(EAMCET 2002)**
(a) *Duranta* (b) *Artabotrys*
(c) *Carissa* (d) *Bougainvillea*

317. A leafy vegetable which has ochraceous stipules is: **(EAMCET 2002)**
(a) *Platanus* (b) *Amaranthus*
(c) *Mentha* (d) *Rumex*

318. Alternate phyllotaxy in which the sixth leaf lies above the first leaf after completing two circles is known as: **(EAMCET 2002)**
(a) Distichous (b) Tristichous
(c) Pentastichous (d) Octastichous

*319. The underground stem of this genus is a rhizome: **(EAMCET 2002)**
(a) *Allium* (b) *Gloriosa*
(c) *Scilla* (d) *Lilium*

320. Leaves arise from which part of plant? **(AFMC 2003)**
(a) Rhizome (b) Stem
(c) Internode (d) Node

ANSWERS

1—b	2—c	3—b	4—d	5—d	6—c	7—c	8—b	9—d	10—b	11—c	12—b
13—d	14—c	15—b	16—d	17—c	18—d	19—b	20—b	21—c	22—b	23—b	24—b
25—a	26—a	27—d	28—d	29—b	30—d	31—b	32—c	33—d	34—b	35—c	36—b
37—b	38—d	39—b	40—b	41—a	42—c	43—c	44—b	45—c	46—d	47—d	48—b
49—c	50—d	51—c	52—b	53—c	54—b	55—b	56—a	57—b	58—b	59—b	60—b
61—c	62—c	63—a	64—b	65—b	66—c	67—d	68—c	69—b	70—c	71—b	72—c
73—b	74—d	75—a	76—c	77—d	78—c	79—d	80—b	81—d	82—a	83—a	84—c
85—a	86—d	87—c	88—b	89—a	90—a	91—a	92—c	93—c	94—c	95—d	96—c
97—a	98—a	99—b	100—d	101—c	102—d	103—b	104—a	105—c	106—a	107—a	108—c
109—a	110—a	111—b	112—b	113—c	114—b	115—d	116—b	117—c	118—c	119—a	120—a
121—b	122—a	123—d	124—a	125—b	126—c	127—b	128—b	129—c	130—b	131—b	132—d
133—b	134—c	135—d	136—a	137—b	138—c	139—d	140—a	141—c	142—c	143—c	144—c
145—d	146—a	147—d	148—a	149—d	150—c	151—c	152—d	153—b	154—c	155—d	156—b
157—a	158—b	159—b	160—b	161—d	162—a	163—d	164—b	165—c	166—b	167—a	168—b
169—c	170—b	171—b	172—a	173—b	174—d	175—d	176—b	177—a	178—b	179—c	180—a
181—c	182—d	183—c	184—c	185—b	186—c	187—c	188—c	189—a	190—b	191—b	192—a
193—c	194—a	195—b	196—a	197—c	198—b	199—c	200—b	201—b	202—b	203—b	204—a
205—c	206—d	207—a	208—c	209—a	210—a	211—c	212—c	213—d	214—c	215—d	216—d
217—d	218—b	219—a	220—c	221—d	222—a	223—d	224—c	225—d	226—c	227—b	228—d
229—c	230—b	231—b	232—d	233—d	234—d	235—b	236—c	237—d	238—c	239—d	240—b
241—b	242—b	243—c	244—b	245—b	246—a	247—b	248—a	249—c	250—b	251—b	252—d
253—b	254—d	255—c	256—c	257—c	258—a	259—c	260—c	261—a	262—d	263—d	264—d
265—a	266—d	267—a	268—a	269—a	270—d	271—b	272—d	273—c	274—d	275—b	276—c
277—b	278—b	279—b	280—a	281—c	282—a	283—d	284—b	285—b	286—b	287—c	288—a
289—a	290—d	291—a	292—c	293—d	294—a	295—d	296—d	297—a	298—a	299—d	300—a
301—b	302—b	303—a	304—c	305—a	306—c	307—a	308—d	309—b	310—a	311—c	312—d
313—d	314—a	315—a	316—a	317—d	318—c	319—b	320—d				

EXPLANATION OF SELECTED QUESTIONS(*)

6. Prickles are superficial (exogenous origin) outgrowths in any part of stem, branch or leaf.
20. An ovule (seed) may be best defined as integumented, indehiscent megasporangium.
22. Time-gap between two successive primordia is called plastochron.
27. Bulb is highly reduced just like a small disc like structure on which many fleshy scale leaves are borne.
56. There is root cap at apex of root and behind it, there is meristematic region.
80. Germination of seeds inside fruit on parent plant is called vivipary.
99. In bulb, food is stored in scaly leaves.
134. Rhizome is modified underground stem and thus shows character of stem, *i.e.*, having buds in axils of scale leaves.
149. Bulb is having greatly reduced stem (disc).
155. Sheathing leaf base and ligule (at junction of leaf sheath and lamina) are characteristics of leaf of members of family gramineae (grasses).
160. Spike of unisexual flowers is called catkin or ament.
205. *Podostemon* is a plant that is all root.
222. Largest bud is of cabbage, which is edible.
255. Inner integument forms tegmen of seed while outer integument forms testa.
261. In *Acacia*, phyllodes (petioles of leaves modified into flat leaf like structures) are present.
273. In *Opuntia*, leaves are reduced to form spines and stem becomes flattened and leaf like to form phylloclades.
288. In *Bougainvillea*, large and coloured bracts are present, which provide beauty to flower.
307. The way in which leaves are arranged in bud constitutes vernation.
312. Seed is the ripened ovule.
313. Castor seed is endospermic and food is stored in endosperm.
315. Here, potato is a stem vegetable while rest three are root vegetables.
319. In *Gloriosa*, stem is underground rhizome.

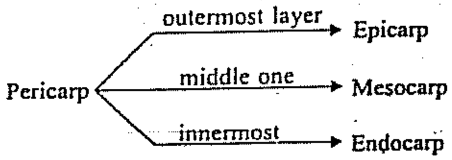
16

Fruits and Dispersal of Seeds and Fruits

- **Fruits :** Types of fruits, Dehiscence of fruits, Edible parts of some fruits
- **Dispersal of seeds and fruits :** Anemochory, Hydrochory, Zoochory, Autochory.

THE FRUIT

The fruit is a ripened ovary. After fertilization, the succulent parenchyma in ovary becomes much developed due to the production of growth hormones. Many acids, sugars and some other substances are produced in these parenchymatous cells. Ovary wall is changed into **pericarp** after ripening.



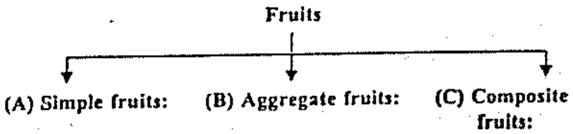
On the basis of the formation of fruits, they are classified into two types:

(i) **True fruits :** The fruits which are developed from the ovary, are known as true fruits.

(ii) **False fruits or spurious fruits or pseudocarps :** When some other floral parts participate in the formation of fruits, *e.g.*, thalamus in apple is modified to form a fruit.

TYPES OF FRUITS

There are three chief types of fruits:



Develop from monocarpellary or multicarpellary syncarpous ovary

Develop from the multicarpellary apocarpous ovary

Develop from the complete inflorescence

(A) Simple fruits

These are divided into two types:

(a) Dry fruits

These fruits have undistinguished dry woody or membranous pericarp and are not fleshy. These fruits are divided into the following three types:

(i) **Dehiscent fruits or Capsular fruits :** Here pericarp is ruptured after ripening of fruit and seeds are dispersed.

(ii) **Indehiscent fruits or Achenial fruits :** Fruits do not dehisce or rupture.

(iii) **Schizocarpic fruits :** In these fruits, carpel or carpels split into one seeded parts, mericarps.

(i) Dehiscent fruits or Capsular fruits

These are divided into following five groups:

1. **Legume or Pod :** Dry monocarpellary fruit developing from a superior one chambered ovary. Mature fruits have one suture on each side, through which these fruits dehisce, *e.g.*, pea, bean, pulses, rattlewort, etc.

2. **Follicle :** Dry monocarpellary, superior one chambered fruit, dehiscence by one suture only. Single follicle is rare, sometimes seen in *Calotropis*. Usually found in pairs, *e.g.*, *Michelia*, *Vinca*, etc.

3. **Siliqua :** This fruit develops from the bicarpellary syncarpous ovary. Ovary unilocular but later on becomes bilocular due to the development of false septum called replum. Dehiscence from lower side towards upper side. **Characteristic fruit of family Cruciferae**, *e.g.*, *Brassica*.

4. **Silicula :** Similar to that of siliqua, but its breadth and length are almost equal, *e.g.*, *Capsella* (shepherd's purse).

5. **Capsule :** Many seeded uni or multilocular fruit develops from a superior or inferior, bi or polycarpellary

ovary. Dehiscence in many ways, *e.g., Datura, Gossypium, Papaver, Hibiscus esculentus, Argemone*, etc.

(ii) Indehiscent or Achenial fruits

1. **Achene** is a small dry, one chambered, one seeded fruit developing from superior or inferior monocarpellary ovary. Pericarp is free from the seed coat. Simple achene is found in few cases, *i.e.*, in four O' clock plant (*Mirabilis*), hog weed, buckwheat, etc. Mostly achenes develop in an aggregate.

2. **Caryopsis or Grain :** Small, dry, one seeded fruit developing from superior monocarpellary ovary. Pericarp fused with the seed coat, *e.g.*, rice, wheat, maize, etc.

3. **Cypsella :** Dry, one chambered, one seeded fruit developing from an inferior, bicarpellary ovary, *i.e.*, in Compositae, *e.g.*, sunflower, marigold, cosmos, etc. Pappus or persistent calyx is present on fruits.

4. **Samara :** One seeded fruits developing from superior bi or tricarpellary ovary. Pericarp becomes flat like wings, *e.g., Holoptelea indica* (Chilbil).

5. **Nut :** Dry, one chambered, one seeded fruit developing from a superior bi or polycarpellary ovary. Pericarp is hard and woody, *e.g.*, cashewnut, *Litchi, Trapa, Oak*, etc.

- The spines present in *Trapa* (water chest nut) are persistent calyx.

(iii) Splitting or Schizocarpic fruits

1. **Lomentum :** Fruits develop from monocarpellary, superior ovary. There are modifications of legumes, partitioned into number of one seeded compartments (mericarps), *e.g., Mimosa pudica, Acacia, Arachis hypogea*, etc.

2. **Cremocarp :** Bilocular, two seeded fruits developing from an inferior bicarpellary ovary. On maturation divides into one seeded pieces mericarps along with carpophore. **Characteristic fruit of Umbelliferae**, *e.g.*, Coriander, *Cuminum*, etc.

3. **Double Samara :** Fruits develop from bicarpellary, syncarpous, superior ovary. Pericarp develops into two wings. On maturation divides into two seeded samara, *e.g., Acer*.

4. **Regma :** Fruits develop from multicarpellary pistil and on maturation split and divide into as many parts equal to the number of carpels. Each one seeded part is known as coccus, *e.g.*, castor has three cocci and *Geranium* has five cocci.

5. **Carcerulus :** Fruits develop from bicarpellary or multicarpellary, syncarpous ovary. Four one seeded locules are formed due to the formation of false septum. Characteristic of *Althaea* and *Abutilon* (Malvaceae) and *Ocimum* (Labiatae).

(b) Succulent or Fleshy fruits

Pericarp is distinguished into three layers. Mesocarp (middle layer) is fleshy or fibrous. These fruits are divided into 6 groups:

1. **Drupe :** One or more chambered, one or more seeded fruit, developing from mono or multicarpellary, syncarpous, superior ovary. Epicarp forms the skin of the fruits. Mesocarp is fleshy and endocarp is hard and stony, *e.g.*, mango, peach, cherry, coconut, almond, walnut, plum, etc.

2. **Berry or Bacca :** Develops from mono or multicarpellary superior or inferior syncarpous ovary with axile or parietal placentation. Epicarp makes the rind of fruit, mesocarp is fleshy and endocarp is thin membranous, *e.g.*, tomato, banana, brinjal, guava, grapes, etc.

- In *Citrus* fruits (orange, lemon, etc.), a special type of berry called **hesperidium** is present in which **epicarp** becomes thick and leathry with oil glands, **mesocarp** is white, fibrous and fused with epicarp whereas **endocarp** is membranous from which **unicellular, juicy hairs** arise which form edible part.

3. **Pome :** Fruits formed from the fleshy thalamus of syncarpous inferior ovary (false fruit). Seeds develop inside the locules. Thalamus edible part, *e.g.*, apple, pear, etc.

4. **Pepo :** This fruit develops from inferior, tricarpellary ovary with parietal placentation. It is characteristic fruit of family Cucurbitaceae, *e.g.*, cucumber, watermelon, etc.

5. **Balausta :** Fruits develop from multilocular syncarpous inferior ovary. Testa is fleshy. The fruit has persistent calyx, *e.g.*, pomegranate.

6. **Amphisarca :** Multicarpellary, syncarpous, multi-chambered superior ovary gives rise to this fruit. Mesocarp, endocarp and swollen placenta are eaten, *i.e., Aegle marmelos* (wood apple).

(B) Aggregate fruits

These fruits develop from multicarpellary apocarpous ovary. They make an aggregate of fruitlets known as etaerio of fruitlets.

Aggregate fruits are of following types:

1. **Etaerio of follicles :** Each separate carpel develops into a fruitlet called follicle. Many follicles form an etaerio, *i.e., Calotropis, Catharanthus, Michelia*, etc.

2. **Etaerio of berries :** Aggregate of small berries, *e.g.*, custard apple. Apical parts of berries fuse with each other to form a common rind.

3. **Etaerio of drupes :** Here many small drupes developed from different carpels are arranged in groups on the fleshy thalamus, *e.g., Rubus idaeus*.

(C) Composite fruits (Multiple fruits)

These fruits are developed from the complete inflorescence and are known as **infructescence**. These are of two types:

1. Sorosis : Spike, spadix or catkin inflorescence give rise to this type of fruits. In pineapple (*Ananas*) and jack fruit (*Artocarpus*), rachis, bracts, perianth are used for eating. Stigmas fuse to make rough and spiny rind in jackfruit. In mulberry, fleshy perianth is eaten.

2. Syconus or Syconium : Develops from a hypanthodium inflorescence. The hollow pear shaped fleshy receptacle encloses a number of minute male and female flowers, it becomes fleshy and forms the fruit, *e.g., Ficus* (banyan, peepal, etc.).

DEHISCENCE OF FRUITS

Fruits dehisce by following methods:

1. Sutural dehiscence : In this type, fruits dehisce by one suture, *e.g.,* in follicle (*Calotropis*) or by two sutures, *e.g.,* in legumes (pea, bean).

2. Porous dehiscence : Usually found in capsule fruit. In this type pores are formed on the upper side of the fruit, through which seeds are dispersed, *e.g., Papaver.*

3. Transverse dehiscence : In this type, pericarp dehisces transversely into two portions. The cap like portion is blown away by the wind, *e.g., Celosia* (cock's comb), *Eucalyptus, Psidium guajava.*

4. Loculicidal dehiscence : The pericarp splits through the middle of locules along with division of placenta, *e.g., Gossypium, Hibiscus,* etc.

5. Septicidal dehiscence : In this type, the septa gets ruptured and locules are separated. Pericarp also gets separated in the form of valves, *e.g.,* linseed, castor, mustard, etc.

6. Septrifragal dehiscence : The placenta remains attached in the centre of fruit and pericarp segments get separated, *e.g., Datura, Cedrela* (toon), etc.

EDIBLE PARTS OF SOME FRUITS

(1) Wheat	Endosperm and embryo
(2) Maize	"
(3) Litchi	Fleshy aril
(4) Orange	Unicellular juicy hairs from endocarp
(5) Lemon	"
(6) Apple	Fleshy thalamus
(7) Pear	"
(8) Strawberry	"
(9) Banana	Mesocarp and endocarp
(10) Cucumber	"
(11) Muskmelon	"
(12) Walnut	Cotyledons
(13) Groundnut	Cotyledons and embryo lobe
(14) Cashewnut	Cotyledons and fleshy pedicel
(15) Pea	Cotyledons and embryo
(16) Pomegranate	Juicy testa
(17) Indian plum	Epicarp and mesocarp
(18) Guava	Pericarp and placenta
(19) Grape	"
(20) Jack fruit	Bracts, perianth and seeds
(21) Pineapple	External rachis, bracts, perianth and seed
(22) Mulberry	Perianth
(23) Fig	Rachis or fleshy receptacle
(24) Coconut	Endosperm
(25) Lotus	Thalamus and seeds
(26) Custard apple	Mesocarp

DISPERSAL OF SEEDS AND FRUITS

Dispersal of seeds and fruits is of great importance and is necessary to avoid the extinction of species. If there is no dispersal then there would have been following situations:

(a) If the seeds and fruits of a plant fall below the mother plant then there might have been a struggle for existence because of the similar basic necessities and no plant will develop properly.

(b) When all plants grow together, they are likely to be destroyed by animals, fire, etc.

The important agencies through which the dispersal of seeds and fruits takes place are:

(A) Dispersal by wind (Anemochory)

The seeds and fruits which are dispersed by wind have following adaptations, which help them to disperse far away from the mother plant:

(a) **Wings :** Seeds of many plants develop one or more appendages in the form of thin membranous wings, which help them to float in air, *e.g., Oroxylon, Cinchona, Moringa, Lagerstroemia, Tecoma, Stereospermum,* etc. In some fruits, pericarp develops some winglike structure, *e.g., Hiptage, Acer, Dioscorea, Shorea robusta, Terminalia, Myriocarpa, Dodonaea,* etc.

(b) **Parachute mechanism :** Appendages of some fruits and some seeds help them to remain in air for a longer time and disperse at a good distance by acting as parachute. The various appendages are as follows:

(i) **Pappus :** In many plants of family Compositae, the calyx is modified into a persistent hairlike structures known as pappus, which open out in a umbrella-like fashion and help them to float in air.

(ii) **Coma :** One or more tufts of hairs are attached on seeds constitute coma, *e.g., Calotropis* (one tuft of hairs or one coma), *Alstonia* seed (two comas are present), *Asclepias,* cotton, etc.

(iii) **Persistent hairy style :** Persistent hairy styles are present in some plants, which help in dispersal, *e.g., Narvelia, Clematis,* etc.

(iv) **Balloon-like appendages :** Persistent calyx in *Physalis,* ovary in *Colutea* and capsule in *Cardiospermum* swell to make balloon like structures, which help the fruits and seeds to remain in air for a longer duration of time.

(c) **Light seeds and fruits :** Some seeds and fruits are so light that they can be easily carried away by wind, *e.g.,* **Orchids** bear the smallest seeds in the vegetable kingdom, which are dustlike and millions in number in a single capsule.

Cinchona has thin, small and extremely light about 2500 seeds in a gram.

(d) **Censer mechanism :** Seeds of certain plants are scattered after dehiscence of fruit when shaken by the wind, *e.g.*, in Poppy (*Papaver*), *Argemone*, *Aristolochia*, *Antirrhinum*, bath sponge, etc.

(B) Dispersal by water (Hydrochory)

Seeds and fruits dispersed by water have floating devices in the form of spongy outer coats, *e.g.*, fibrous mesocarp in coconut and in double coconut (*Lodoicea maldivica)* (its seed **is two lobed, fruit weighing 18 kg or more, measuring a metre in length, takes 6–10 years to ripe).**

Sometimes the seeds are small and light and float on water, *e.g.*, seeds of water lily.

(C) Dispersal by animals (Zoochory)

Some fruits and seeds develop certain adapting organs for this purpose.

(a) **Hooked fruits and seeds :** Some fruits and seeds are provided with hooks, barbs, spines, bristles, stiff hairs, etc., on their body, *e.g.*,

(i) Seeds of *Xanthium*, *Urena*, etc., are covered with numerous hooks.

(ii) Spikelets of love thorn (*Chrysopogon*) and seeds of **spear grass** (*Aristida*) are provided with a cluster of minute hairs pointing upwards.

(iii) Flower cluster of *Pupalia* bear stellate hooked bristles.

(iv) Seeds of **Tiger's nail** (*Martynia annua*) are provided with two very sharp pointed stiff and bent hooks for effective dispersion by woolly animals.

(v) In *Tribulus* (**Gokhru**), there are sharp rigid spines on the fruit.

(b) **Sticky fruits and seeds :** Fruits of *Boerhaavia* and *Plumbago* have sticky glands on their body. Seeds of **mistletoe** (*Viscum*) are very sticky and dispersed by birds.

o Sticky seeds of *Rafflesia* are dispersed by elephants.

(c) **Fleshy fruits :** These fruits are coloured and attractive, *i.e.*, *Solanum nigrum*, *Citrullus*, etc., because of which they are carried away by the animals.

(d) **Edible fruits :** Human beings and birds are active and useful agents in distributing these fruits. Commonly birds feed upon the pulpy portion of fruits and pass out seeds with faeces, *i.e.*, guava, grape, plums, tomato, brinjals, apricot, etc.

(e) **Mimicry :** Dispersal of fruits by mimicry occurs in *Biserula* and *Scorpiurus*. The fruits (legumes) of these plants resemble a catterpillar and they can be taken away by birds by mistake.

(D) Dispersal by explosive fruits (Autochory)

Many fruits burst with a sudden jerk because of which the seeds are scattered a few yards from the parent plant. Some of the common examples are balsam (*Impatiens*), wood sorrel (*Oxalis*), night jasmine (*Nyctanthes*), castor (*Ricinus*), etc. Another example of autochory is the seeds of *Ecballium* **(squirting cucumber)**. Many plants of **Acanthaceae** bear explosive fruits. Dry fruits of *Ruellia tuberosa* coming in contact with water burst into two valves. Mature fruits of *Andrographis*, *Barleria*, *Acanthus*, *Phlox*, etc., burst suddenly when the air is dry. In *Andrographis*, *Barleria* and *Ruellia*, the seeds are born on retinacula or jaculators, which push out the seeds with a jerk and thus dispersal occurs by **jaculator mechanism.**

In camel's foot climber (*Bauhinia vahilii*), the long pods (more than 30 cm in length) explode violently with a loud noise scattering the seeds in all directions.

MULTIPLE-CHOICE QUESTIONS

1. Brinjal is a fruit:
(a) False (b) True
(c) Parthenocarpic (d) Aggregate

2. Custard apple is a fruit:
[✓ (a) Aggregate] (b) Composite
(c) Simple (d) None of these

3. The fruit of candytuft is:
(a) Siliqua (b) Silicula
(c) Capsule (d) Legume

4. Lomentum type of fruit is found in:
(a) Pea (b) Lady's finger
(c) *Acacia* (d) *Cicer*

***5.** Which of the following structure changes into pericarp after ripening?
(a) Seed coat (Testa) (b) Tegmen
(c) Ovary wall (d) Placenta

6. Which of the following fruit is 'false'?
(a) Pea (b) *Papaver*
(c) Pear (d) Mango

7. Apple is a type of fruit:
(a) True (b) Dry
(c) Spurious (d) Aggregate

8. 'Porous dehiscence' of fruit occurs in:
(a) *Calotropis* (b) *Papaver*
(c) *Eucalyptus* (d) *Datura*

9. Septifragal dehiscence occurs in:
(a) *Gossypium* (b) *Datura*
(c) *Papaver* (d) *Calotropis*

10. Achenical fruits are:
(a) Dehiscent (b) Indehiscent
(c) Schizocarpic (d) None of these

11. The fruit which develops from hypanthodium inflorescence is: **(AFMC 1992)**
(a) Sorosis (b) Syconus
(c) Berry (d) Capsule

12. The example of carcerule is:
(a) Hollyhock (b) Anise
(c) Castor (d) Coriander

13. Fruit of fennel is:
(a) Carcerulus (b) Capsule
(c) Lomentum (d) Cremocarp

14. Banana is:
(a) Berry (b) Pome
(c) Pepo (d) Balausta

15. Pomegranate has a fruit:
(a) Berry (b) Samara
(c) Balausta (d) Carcerule

16. A simple one seeded fruit with pericarp fused with seed coat is:
(a) Caryopsis (b) Achene
(c) Cypsella (d) Follicle

17. The fruit which develops from a simple, superior, monocarpellary ovary and dehisce by one suture only:
(a) Legume (b) Follicle
(c) Siliqua (d) Capsule

***18.** It will be useless to produce seedless fruits in:
(a) Mango (b) Pomegranate
(c) Watermelon (d) Orange

19. Which is a parthenocarpic fruit?
(a) Orange (b) Banana
(c) Mango (d) Custard apple

20. Which is not a fruit?
(a) Tomato (b) Cucumber
(c) Potato (d) Pumpkin

21. The edible portion of fig is:
(a) Receptacle (b) Endocarp
(c) Mesocarp (d) Juicy hair

22. Which fruit is a type of true nut? **(AIIMS 1990)**
(a) Groundnut (b) Arecanut
(c) Walnut (d) Cashewnut

23. The edible part in orange is:
(a) Unicellular placental hair
(b) Unicellular endocarpic hair
(c) Multicellular endocarpic hair
(d) Multicelled placental hair

24. In Anar, the edible part of fruit is:
(a) Juicy epicarp
(b) Mesocarp
(c) Juicy hair from endocarp
(d) Juicy testa

25. 'Chilgoza' is a seed of:
(a) Chilbil (b) Sunflower
(c) Coconut (d) *Pinus*

26. The edible part in Apple is: **(BHU 1996)**
(a) Mesocarp (b) Cotyledons
(c) Thalamus (d) Endocarp

27. A fruit which develops from a multicarpellary pistil and on maturation splits in to many one-seeded portions called cocci is called:
(a) Lomentum (b) Carcerulus
(c) Cremocarp (d) Regma

28. Fruits which develop from multicarpellary apocarpous ovary are:
(a) Schizocarpic (b) Composite
(c) Aggregate (d) Multiple

29. In jack fruit, rough and spiny rind is formed by:
(a) Fusion of bracts (b) Fusion of perianth
(c) Fusion of stigmas (d) Rachis

30. The edible part in mulberry is: **(Uttaranchal PMT 2001)**
(a) Rachis, bracts and perianth
(b) Perianth
(c) Bracts, perianth and seeds
(d) Fleshy mesocarp

31. In grapes, what is eaten?
(a) Epicarp and Mesocarp (b) Pericarp and placenta
(c) Fleshy thalamus (d) Aril

***32.** Fleshy aril (Third integument) represents edible portion in: **(CBSE 1997)**
(a) Guava (b) Grape
(c) Litchi (d) Lemon

33. Amphisarca is a characteristic fruit of:
(a) Wood apple (b) Apple
(c) Date palm (d) None of these

34. Small, dry, one seeded fruit, where pericarp is free from seed coat, is:
(a) Grain (b) Cypsella
(c) Achene (d) None of these

35. Fruit is Silicula in:
(a) *Brassica* (b) *Michelia*
(c) Shepherd's purse (d) Apple

36. Parachute mechanism of dispersal of fruits is due to:
(a) Pappus (b) Coma
(c) Persistant hairy styles (d) All of these

37. Stony fruit is:
(a) Berry (b) Drupe
(c) Nut (d) Samara

38. In *Oxalis*, dispersal of seeds is by:
(a) Animals (b) Wind
(c) Explosion of fruits (d) Water

39. Dispersal with the help of 'Coma' occurs in:
(a) *Calotropis* (b) *Clematis*
(c) *Physalis* (d) Sunflower

***40.** Maize grain is a:
(a) Seed (b) Fruit
(c) Embryo (d) None of these

41. The edible portion in 'water chest nut' is:
(a) Endocarp (b) Mesocarp
(c) Cotyledons (d) None of these

42. *Tribulus* fruits are dispersed by:
(a) Animals (b) Water
(c) Wind (d) None of these

***43.** In which of the following the ripened ovary forms an inedible core?
(a) *Pyrus malus* (b) *Mangifera indica*
(c) *Psidium guajava* (d) *Cocos nucifera*

44. 'Censer Mechanism' of fruit dispersal is in:
(a) *Papaver* (b) *Argemone*
(c) *Aristolochia* (d) All of these

45. Winged seeds are found in:
(a) *Shorea* (b) *Moringa*
(c) Hiptage (d) *Calotropis*

46. The edible portion in walnut is:
(a) Endocarp (b) Thalamus
(c) Cotyledons (d) None of these

47. Litchi is a type of fruit:
(a) Drupe (b) Berry
(c) Nut (d) Capsule

48. The fruit developed from a complete condensed inflorescence is: **(Pb. PMT 1997; DPMT 1997)**
(a) Simple (b) False
(c) Composite (d) Aggregate

49. Edible part of coconut is: **(MDAT Bihar 1991; CPMT 2001)**
(a) Seed coat (b) Pericarp
(c) Endosperm (d) Mesocarp

50. Which has the winged fruit?
(a) *Shorea* (b) *Dioscoria*
(c) *Dodonaea* (d) All of these

51. The largest fruit is of:
(a) *Cocos nucifera* (b) Jack fruit
(c) *Cucurbita* (d) *Lodoicea*

52. Smallest seeds in vegetable kingdom are in:
(a) *Cinchona* (b) Orchid
(c) Spinach (d) Grasses

53. Which of the following is called 'Tiger's Nail'?
(a) *Tribulus* (b) *Xanthium*
(c) *Martynia* (d) *Aristida*

54. 'Old Man's beard' is common name of:
(a) *Aristida* (b) *Helianthus*
(c) *Calotropis* (d) *Clematis*

55. Sticky seeds are in:
(a) *Boerhaavia* (b) *Plumbago*
(c) *Viscum* (d) All of these

56. In camel's foot climber, the dispersal of seeds is by:
(a) Parachute mechanism (b) Censer mechanism
(c) Explosive mechanism (d) None of these

57. The fruits of which suddenly explode on coming in contact with water:
(a) *Barleria* (b) *Balsam*
(c) *Ruelia* (d) *Phlox*

58. As many as 2500 seeds/gram are present in:
(a) Orchids (b) *Cinchona*
(c) *Papaver* (d) *Lodoicea*

59. Receptacle grows, becomes fleshy and edible in:
(a) Berry (b) Follicle
(c) Drupe (d) Pome

60. The fruit of compositae is:
(a) Berry (b) Cypsela
(c) Drupe (d) Capsule

61. The fruit of Pineapple is really a: **(DPMT 1997)**
(a) Pome
(b) Aggregate fruit or achene
(c) Drupe or pepo
(d) Multiple fruit or sorosis

62. Bananas are seedless because they:
(a) Are sprayed with auxins
(b) Reproduce sexually
(c) Have plenty of cytokinins
(d) Are triploids

63. The edible portion in lotus is:
(a) Mesocarp (b) Endosperm
(c) Cotyledons (d) Aril

64. The oil reserves in groundnut is stored in: (CBSE 1990)
(a) Embryo (b) Underground tubers
(c) Endosperm (d) Cotyledons

65. The fruit of onion is: (AFMC 1991)
(a) Capsule (b) Caryopsis
(c) Tunicated bulb (d) Achene

66. The characteristic fruit of family cruciferae is: (BHU 1993)
(a) Capsule (b) Siliqua
(c) Legume (d) Berry

67. Which one of the following fruits is derived from a monocarpellate pistil?
(a) Capsule (b) Samara
(c) Legume (d) Pome

*68. The most important foods are derived from:
(a) Roots (b) Fruits
(c) Stems (d) Leaves

69. The edible part of apple and pear is: (Re. Ex. CPMT 1991; EAMCET 1992)
(a) Epicarp (b) Mesocarp
(c) Endocarp (d) Thalamus

70. The type of fruit in groundnut (*Arachis*) is:
(a) Nut (b) Legume
(c) Berry (d) Caryopsis

71. Wheat grain is a fruit known as: (CPMT 2001)
(a) Caryopsis (b) Achene
(c) Cypsela (d) Samara

72. Dispersal of *Papaver* seeds is by: (CPMT 1992)
(a) Animal (b) Wind
(c) Water (d) Censer mechanism

*73. Where two carpels of a flower give rise to two fruits, it can be a:
(a) Siliqua (b) Silicula
(c) Etaerio of follicle (d) Capsule

74. Which one of the following is an example of septifragal fruit?
(a) Lady's finger (b) Cotton
(c) Poppy (d) *Datura*

75. What do we eat in cashewnut?
(a) Fleshy cotyledons and thalamus
(b) Whole seed
(c) Whole fruit
(d) Fleshy calyx

76. The fruit that develops from a single ovary of a flower is a: (AMU 1990)
(a) Simple fruit (b) Composite fruit
(c) Aggregate fruit (d) False fruit

77. In *Clematis* and *Narvelia*, dispersal of fruits takes place by wind. Which of the following structure helps in dispersal?
(a) Bracts (b) Pappus
(c) Persistent styles (d) Hairs

*78. Seedless fruit can be obtained by:
(a) Treatment with enzymes
(b) Treatment with hormones
(c) Keeping the plants at 70°C
(d) Keeping the plants in brilliant light

79. Lomentum is a term used to describe a kind of:
(a) Seed (b) Inflorescence
(c) Outgrowth from seed (d) Fruit

80. Morphological nature of edible part in apple is:
(a) Cotyledons (b) Mesocarp
(c) Fleshy thalamus (d) Endocarp

81. Edible part of Areca nut is:
(a) Endosperm (b) Seed coat
(c) Mesocarp (d) Endocarp

82. Lomentum fruit is found in:
(a) Tamarind (b) Apple
(c) Castor (d) Coriander

83. The edible part of ground nut is burried in the soil and morphologically it is a: (MPPMT 1995)
(a) Root (b) Stem
(c) Fruit (d) Leaf

84. Dispersal of coconut fruit takes place by: (Pondicherry 1990)
(a) Air (b) Water
(c) Animal (d) Splitting

85. Inflorescence and fruit of sunflower is: (AFMC 1991)
(a) Capitulum and achene (b) Corymb and cypsela
(c) Capitulum and cypsela (d) Corymb and achene

86. Fruits are not found in gymnospermous plants because:
(a) They are seedless plants
(b) They are not pollinated
(c) They have no ovary
(d) The process of fertilization does not takes place in them

87. Composite fruit develops from:
(a) Multicarpellary apocarpus ovary
(b) Multicarpellary syncarpus ovary
(c) Entire inflorescence
(d) Multicarpellary inferior ovary

88. Which one of the following is a good source of vitamin A?
(a) Banana (b) Mango
(c) Gram (d) Wheat

*89. For fruit formation, calyx is: (CPMT 1994)
(a) Inhibitory (b) Ineffective
(c) Promotory (d) Toxic

90. The fruits of coconut and almond are:
(a) Nut (b) Drupe
(c) Berry (d) None of these

91. The fruit of mustard is:
(a) Siliqua (b) Silicula
(c) Legume (d) Lomentum

*92. Style and stigma of which plant are edible and used as food? (CBSE 1992)
(a) *Corchorus* (b) *Crocus* (Saffron)
(c) *Coffea arabica* (Coffee) (d) Maize

93. Caryopsis is a fruit of: (CPMT 1994)
(a) Wheat (b) Pea
(c) Apple (d) Coconut

94. Fleshy part of apple, pear and cashew nut is:
(a) Pericarp (b) Mesocarp
(c) Thalamus/pedicel (d) Peduncle

95. In *Mangifera indica* the fruit is:
(a) Berry (b) Drupe
(c) Capsule (d) Pepo

96. Milky water of green coconut is: **(CPMT 1990)**
(a) Liquid nucellus
(b) Liquid of female gametophyte
(c) Liquid endosperm
(d) Liquid chalaza

97. Mango juice is obtained from: **(CBSE 2002; BCECE 2002)**
(a) Mesocarp (b) Epicarp
(c) Endocarp (d) Pericarp and thalamus

98. In tamarind the edible part is:
(a) Epicarp of berry
(b) Testa and tegmen of albuminous seeds
(c) Mesocarp and endocarp of lomentum
(d) Mesocarp of siliqua

99. Pome is a false fruit because: **(CPMT 2000)**
(a) It develops from a false ovary
(b) Real fruit is inside fleshy thalamus
(c) Pericarp is absent
(d) None of the above

100. Aggregate fruit develops from: **(BHU 1995)**
(a) Multicarpellary ovary
(b) Multicarpellary syncarpous ovary
(c) Multicarpellary apocarpous ovary
(d) Whole inflorescence

101. Parthenocarpic fruit means:
(a) A fruit with immature seeds
(b) A seedless fruit
(c) A fruit developed without pollination or fertilization
(d) A fruit without the pulp

102. Immature 'Fig' or 'Gular' fruit is:
(a) Berry (b) Hypanthodium
(c) Samara (d) Pepo

103. Seeds of which plant are dispersed by jaculators?
(a) Tomato (b) *Hiptage*
(c) *Ecballium* (d) *Ruellia*

104. In pineapple, mulberry, jack fruit and fig, the fruits develop from inflorescence, such fruits are called as:
(a) Simple fruit (b) Aggregate fruit
(c) False fruit (d) Multiple fruit

105. The fruit in which mesocarp is fleshy and endocarp is stony is known as:
(a) Pome (b) Berry
(c) Drupe (d) Pepo

106. Wind-dispersed seeds and fruits tend to have:
(a) Barbs or hooks (b) Hairs or wings
(c) Sticky surfaces (d) Rounded, compact shape

***107.** Bitterness of cucurbits is due to:
(a) The acid present in them
(b) The alkalinity in their pulp
(c) The occurrence of triterpenes
(d) The presence of bitter seeds in them

108. To which of the following can the survival of flowering plants be assigned best?
(a) Ability to carry on vegetative propagation
(b) Absence of vascular system
(c) Development of the fruit
(d) Development of an extensive root system

109. The fruit of coconut is a: **[BCECE (P.T. Exam.) 2001]**
(a) Berry (b) Nut
(c) Drupe (d) None of these

110. A carpel develops into:
(a) Plant (b) Seed
(c) Fruit (d) Flower

111. The edible part of ripe mango is morphologically:
(CBSE 1990; AFMC 1996)
(a) Epicarp (b) Mesocarp
(c) Pericarp (d) Endocarp

112. Mulberry fruit is:
(a) Aggregate fruit (b) Composite fruit
(c) Dry fruit (d) Simple fruit

113. The edible part of cucumber is:
(a) Mesocarp
(b) Endocarp
(c) Placenta, pericarp, thalamus and seeds
(d) Pericarp and thalamus

114. Caryopsis is the fruit of:
(a) Tomato (b) Maize (or gramineae)
(c) Brinjal (d) Coconut

115. A dry, one-celled and one-seeded fruit developing from a bicarpellary inferior ovary, often with persistent pappus is termed as:
(a) Nut (b) Cypsela
(c) Caryopsis (d) Achene

116. Fleshy peduncle and cotyledons are edible in:
(a) Cashewnut (b) Coconut
(c) Banana (d) Cucumber

117. Chestnut is a rich source of:
(a) Protein (b) Carbohydrate
(c) Oil (d) All of these

118. In poppy dehiscence of fruit is:
(a) Transverse (b) Longitudinal
(c) Porous (d) Valvular

119. The wheat grain is: **(MPPMT 1993; BHU 2001)**
(a) Fruit (b) Seed
(c) Embryo (d) Glume

120. Fruits of apple are regarded false because:
(a) Its pericarp is inconspicuous
(b) It develops from an inferior ovary
(c) Actual fruit is located inside the edible thalamus
(d) It is fleshy in nature

121. Among the following sets of fruits, those that belong to the same category from the point of view of classification are:
(BHU 1990)
(a) Coconut, chestnut and cashewnut
(b) Coconut, betelnut and chestnut
(c) Coconut, mango and almond
(d) Coconut, orange and tomato

122. Dry indehiscent one seeded fruit derived from inferior bicarpellary ovary is known as: (CPMT 1991)
(a) Cypsela (b) Nut
(c) Cremocarp (d) Legume

123. *Annona squamosa* is:
(a) Etaerio of achenes (b) Etaerio of drupes
(c) Etaerio of berries (d) Hypanthodium

124. The fruit pepo is found in: (Re. Ex. CPMT 1991)
(a) Cucurbitaceae (b) Cruciferae
(c) Leguminosae (d) Liliaceae

125. Mango is a: (CBSE 1991)
(a) Drupe (b) Legume
(c) Nut (d) Berry

126. Lotus fruit is:
(a) Capsule (b) Etaerio of achenes
(c) Berry (d) Etaerio of berries

127. When the pericarp is fused with testa and the fruit contains a single seed, it is called?
(a) Caryopsis (b) Achene
(c) Utricle (d) Nut

128. Which type of fruit is found in rice? (MPPMT 1993)
(a) Legume (b) Caryopsis
(c) Drupe (d) Berry

129. Geocarpic movement of flower for hypogeal development of fruit (under the ground) occurs in:
(a) *Abrus* (b) *Hibiscus*
(c) *Arachis* (d) *Cicer*

130. For which of the following parthenocarpy is undesirable?
(a) Coconut (b) Tomato
(c) Banana (d) Grapes

131. Which of the following genera is characterised by the production of geocarpic fruits? (CBSE 2000, 2002)
(a) *Cucurbita* (b) *Pisum*
(c) *Glycine* (d) *Arachis*

132. Nut type of fruits are:
(a) Dry dehiscent
(b) Dry indehiscent
(c) Schizocarpic
(d) Fleshy with stony endocarp

133. Walnut and arecanut (betelnut) fruits are respectively:
(a) Nut and nut (b) Drupe and nut
(c) Nut and fibrous berry (d) Drupe and fibrous berry

134. A one-chambered, one-seeded indehiscent fruit developed from bicarpellary, syncarpous, inferior ovary is: (BHU 1993)
(a) Berry (b) Caryopsis
(c) Nut (d) Cypsela

135. Edible part of *Litchi* fruit is: (BHU 1992; DPMT 2003)
(a) Mesoderm (b) Cotyledons
(c) Endosperm (d) Fleshy aril

136. The fruit of tomato can be described as:
(a) A berry, since the entire ovary wall ripens into fleshy fruit tissue
(b) A capsule, since it is derived from a compound pistil
(c) Aggregate, since it is derived from a pentacarpellary pistil
(d) A pome, as the entire fruit wall is fleshy and the fruit has many seeds

137. What is the fruit of a 'fig' plant?
(a) Berry (b) Aggregate fruit
(c) Syconus (d) Pepo

138. Which combination is not correct with respect to edible part of the fruit? (CPMT 1992)
(a) Groundnut–embryo and cotyledons
(b) *Litchi*—fleshy aril
(c) Coconut—endocarp
(d) Mango—mesocarp

139. Dispersal of seeds in opium (poppy) takes place by:
(a) Censer mechanism (b) Explosive mechanism
(c) Parachute mechanism (d) None of these

140. Parachute mechanism of fruit and seed dispersal common in Compositae, is due to the structure called:
(a) Thorns (b) Pappus
(c) Bracts (d) Corolla

141. Which of the following plants are likely to have wide range of distribution?
(a) Those distributed by vegetative means
(b) Those distributed by fruits
(c) Those distributed by seeds
(d) Those distributed by spores

142. A caryopsis is a fruit in:
(a) Tomato (b) Maize (or Gramineae)
(c) Brinjal (d) Coconut

143. A berry is a fruit which is:
(a) Fibrous and single-seeded
(b) Fleshy and single-seeded
(c) Fleshy and multi-seeded
(d) Dry and multi-seeded

144. The fruit of castor is:
(a) Regma (b) Cremocarp
(c) Carcerulus (d) Lomentum

145. Drupe is recognised by:
(a) Stony endocarp (b) Stony mesocarp
(c) Fleshy seed coat (d) Thin seed coat

146. In which fruit the pericarp develops into winglike structure?
(a) Cypsela (b) Samara
(c) Achene (d) Lomentum

147. A fruit which is formed from a condensed inflorescence is termed as: (AFMC 1994)
(a) An etaerio of fruit (b) An aggregate of fruit
(c) A composite fruit (d) A simple fruit

148. Fruit growers grow two or more varieties of fruits in their orchard to have:
(a) Hybridization and production of new varieties
(b) More income
(c) Less disease
(d) Less difficulty in selling the fruits

149. The fruits that develop from a single ovary of single flower is a:
(a) Simple fruit (b) Composite fruit
(c) Aggregate fruit (d) False fruit

150. Which one of the following is a false fruit?
(a) Apple (b) Walnut
(c) Mango (d) Cashewnut

151. The characteristic fruit of family Gramineae is:
(a) Achene (b) Capsule
(c) Cypsela (d) Caryopsis

152. Seeds of orchid are:
(a) Light and dry (b) Small and sticky
(c) Very large and heavy (d) None of these

153. The fruit of which plants are dispersed by grazing animals such as goats and cows?
(a) *Cucurbita* (b) Sunflower
(c) *Xanthium* (d) Mustard

154. Which one of the following fruits is schizocarpic?
(a) Cypsela of Sunflower (b) Lomentum of *Acacia*
(c) Hesperidium of orange (d) Pome of apple

155. In which of the following plants the seeds are beset with tiger's claw? **(CPMT 1992)**
(a) Puncture vine (b) *Martynia*
(c) Spear grass (d) *Xanthium*

156. The fleshy indehiscent fruit which develops from tricarpellary, syncarpous, inferior ovary with parietal placentation is: **(CPMT 1990)**
(a) Hesperidium (b) Pome
(c) Pepo (d) Syconus

157. Fruits are formed in:
(a) *Cycas* (b) *Pinus*
(c) *Brassica* (d) *Funaria*

158. The fruit of opium poppy (*Papaver somniferum*) is: **(BHU 1990)**
(a) Berry (b) Pepo
(c) Loculicidal capsule (d) Porous capsule

159. Seeds of *Ecballium* are dispersed by:
(a) Wind (b) Water
(c) Animals (d) Explosive mechanism

160. Dispersal of seeds of orchids and *Cinchona* occurs by:
(a) Wind (b) Animals
(c) Water (d) Censer mechanism

161. 'Regma' fruit divides into many parts (equal to number of carpels). Each of these parts is known as:
(a) Coccus (b) Carpel
(c) Mericarp (d) None of these

162. In cremocarp fruit, two halves (mericarps) are joined by a common thread like structure, called:
(a) Carpophore (b) Retinaculi
(c) Gynostegium (d) Pollinium

163. Non-living pollens may initiate development of fruit, because the dead pollens produce:
(a) Necroharmone (b) Auxin
(c) Gibberellins (d) Ethylene

164. Dispersal of seeds by 'comose' mechanism occurs in:
(a) Mustard (b) Cotton
(c) Pea (d) Tomato

165. Among the following, name the plant in which seeds are dispersed by wind:
(a) Calotropis (b) Rice
(c) *Cycas* (d) Petunia

166. Vivipary in plants means:
(a) Germination of seeds in the crevices of stem
(b) Development of peanut fruits after the fertilized seed have burrowed them in soil
(c) Organization of several shoots
(d) Germination of seeds inside the fruit, while it is still on the parent tree

167. Seeds in *Rafflesia* show:
(a) Autochory (b) Anemochory
(c) Zoochory (d) Hydrochory

168. In samara fruit, the wings develop from:
(a) Calyx (b) Pericarp
(c) Bracts (d) Corolla

169. Jaculators are present in:
(a) *Ruellia* (b) *Ecballium*
(c) *Impatiens* (d) None of these

170. Dispersal of fruits and seeds by explosive mechanism is called:
(a) Autochory (b) Anemochory
(c) Hydrochory (d) None of these

***171.** Dispersal of fruits by 'mimicry' occurs in:
(a) *Biserula* (b) *Scorpiurus*
(c) *Ecballium* (d) Both (a) and (b)

172. Edible part in *Carica papaya* is:
(a) Epicarp (b) Mesocarp
(c) Pericarp and placenta (d) All of these

173. What do we eat in water-melon?
(a) Mesocarp, endocarp
(b) Mesocarp, endocarp and seeds
(c) Mesocarp, endocarp and cotyledons
(d) Pericarp and placenta

174. Edible portion of *Fragaria* (Strawberry) is:
(a) Thalamus (b) Pericarp
(c) Placenta (d) Both (b) and (c)

175. In *Eriobotrya*, we eat:
(a) Mesocarp (b) Mesocarp and endocarp
(c) Endocarp (d) Pericarp and placenta

176. Which of the following is a true fruit? **(CBSE 1996)**
(a) Pear (b) Coconut
(c) Apple (d) Cashew nut

177. A true fruit is that, in which:
(a) Calyx surrounds the fruit at maturity
(b) Thalamus is well developed
(c) Ovules are well developed
(d) Well developed ovary

178. When some other floral parts other than ovary participates in fruit formation, it is called:
(a) False fruit (b) Spurious fruit
(c) Pseudocarp (d) All of these

179. Fruit is lomentum in:
(a) *Mimosa* (b) *Acacia*
(c) *Arachis* (d) All of these

180. Which of the following is succulent (fleshy) fruit?
(a) Drupe (b) Regma
(c) Cremocarp (d) Lomentum

181. The fruit of apple is said to be a false fruit because: **(DPMT 1992)**
(a) Its pericarp is inconspicuous
(b) Its endocarp is cartilaginous
(c) Its actual fruit is located within an edible fleshy thalamus (pseudocarp)
(d) It develops from an inferior ovary

182. An aggregate of simple fruits borne by a single flower is known as: **(BHU 1996, 2001)**
(a) Berry (b) Cypsella
(c) Caryopsis (d) Etaerio

183. Artificial ripening of fruits is triggered or accomplished by treatment with: **(BHU 1991)**
(a) Sodium chloride (b) IAA
(c) Ethylene gas (d) Conc. sulphuric acid

*184. Winged fruits are commonly called: **(CET Chandigarh 1997)**
(a) Cypsela (b) Samara
(c) Regma (d) Siliqua

185. Which of the following is the fruit of *Hibiscus esculentus*? **(DPMT 1997)**
(a) Cypsela (b) Capsule
(c) Legume (d) Pome

186. Dispersal by animal occurs in: **(CPMT 1998)**
(a) *Xanthium* (b) *Bauhinia*
(c) *Geranium* (d) *Argemone*

187. Parachute mechanism is found in: **(CPMT 1998)**
(a) Compositae (b) Cruciferae
(c) Solanaceae (d) Gramineae

188. A fruit having an endocarp with sub-epidermal juice sacs or hairs on the inner side of its locules, a spongy white mesocarp and leathery epicarp having oil glands is called: **(AFMC 1998)**
(a) Pome (b) Pepo
(c) Drupe (d) Hesperidium

189. Syconus (syconium) type of fruit develops from which type of inflorescence? **(CPMT 1999, 2001; BHU 2002)**
(a) Cyathium (b) Hypanthodium
(c) Catkin (d) Spike

190. In sorosis fruit, the edible part is: **(BHU 1999)**
(a) Perianth and seed (b) Thalamus
(c) Cotyledons (d) Mesocarp

191. Censer mechanism is found in: **(CPMT 2000)**
(a) Leguminosae (b) Papaveraceae
(c) Compositae (d) Liliaceae

192. When we eat pear, some studdiness is experienced which is due to: **(CPMT 2001)**
(a) Stone cells (b) Latex cells
(c) Reticular cells (d) Chlorenchyma

193. Development of fruit without fertilization is known as: **(Uttaranchal PMT 2001)**
(a) Parthenogenesis (b) Parthenocarpy
(c) Apospory (d) Apogamy

194. Edible part of banana is: **(CBSE 2001)**
(a) Epicarp
(b) Mesocarp and less developed endocarp
(c) Endocarp and less developed mesocarp
(d) Epicarp and mesocarp

*195. The production of seedless fruits is called: **(AFMC 2001)**
(a) Pollination (b) Ovulation
(c) Parthenocarpy (d) Eugenics

196. In which plant two curved hooks are formed on the seed? **(EAMCET 2002)**
(a) *Xanthium* (b) *Martynia*
(c) *Tribulus* (d) *Ricinus*

197. Syconus is the name of: **(Haryana PMT 2001)**
(a) Fruit (b) Inflorescence
(c) Ovary (d) Thalamus

198. The pod fruit develops from: **(Raj. PMT 2001)**
(a) Inferior ovary (b) Monocarpellary ovary
(c) Bicarpellary ovary (d) Multicarpellary ovary

199. The nature of a fruit developing from a flower depends on the type of: **(CET Karnataka 2002)**
(a) Pollination (b) Gynoecium
(c) Androecium (d) Fertilization

200. Berries, drupes and pomes are: **(CET J&K 2002)**
(a) Simple dry fruits (b) Simple succulent fruits
(c) Aggregate fruits (d) Composite fruits

201. Jack fruit is derived from: **(Orissa JEE 2003)**
(a) An inflorescence
(b) All carpels in a flower
(c) One ovary of a single flower
(d) Thalamus

202. Juicy hair-like structures observed in the lemon fruit develop from: **(CBSE 2003)**
(a) Exocarp (b) Mesocarp
(c) Endocarp (d) Both (a) and (b)

ANSWERS

1—b	2—a	3—b	4—c	5—c	6—c	7—c	8—b	9—b	10—b	11—b	12—a
13—d	14—a	15—c	16—a	17—b	18—b	19—b	20—c	21—a	22—d	23—b	24—d
25—d	26—c	27—d	28—c	29—c	30—b	31—b	32—c	33—a	34—c	35—c	36—d
37—b	38—c	39—a	40—b	41—c	42—a	43—a	44—d	45—b	46—c	47—c	48—c
49—c	50—d	51—d	52—b	53—c	54—d	55—c	56—c	57—c	58—b	59—d	60—b
61—d	62—d	63—c	64—d	65—a	66—b	67—c	68—b	69—d	70—b	71—a	72—d
73—c	74—d	75—a	76—a	77—c	78—b	79—d	80—c	81—a	82—a	83—c	84—b
85—c	86—c	87—c	88—b	89—c	90—b	91—a	92—b	93—a	94—c	95—b	96—c
97—a	98—c	99—b	100—c	101—c	102—b	103—d	104—d	105—c	106—b	107—c	108—c
109—c	110—c	111—b	112—b	113—c	114—b	115—b	116—a	117—b	118—c	119—a	120—c
121—c	122—a	123—c	124—a	125—a	126—b	127—a	128—b	129—c	130—a	131—d	132—b
133—d	134—d	135—d	136—a	137—c	138—c	139—a	140—b	141—b	142—b	143—c	144—a
145—a	146—b	147—c	148—c	149—a	150—a	151—d	152—a	153—c	154—b	155—b	156—c
157—c	158—d	159—d	160—a	161—a	162—a	163—a	164—b	165—a	166—d	167—c	168—b
169—a	170—a	171—d	172—b	173—c	174—a	175—a	176—b	177—d	178—d	179—d	180—a
181—c	182—d	183—c	184—b	185—b	186—a	187—a	188—d	189—b	190—a	191—b	192—a
193—b	194—c	195—c	196—b	197—a	198—b	199—b	200—b	201—a	202—c		

EXPLANATION OF SELECTED QUESTIONS (*)

5. As ripened ovary forms a fruit hence ovary wall is changed into fruit wall or pericarp.

18. As juicy testa forms edible part in pomegranate (*Punica*), hence seedless fruits are useless here.

32. Fleshy aril or a kind of third integument is edible part in *Litchi*.

40. Grain or Caryopsis is a type of fruit, present in family gramineae.

43. In apple (*Pyrus malus*), thalamus becomes fleshy and edible and actual fruit (ripened ovary) forms central inedible part.

68. Most important foods are derived from grains (fruits) of cereals (gramineae family).

73. When two carpels give rise to two separate fruits, it means fruit is aggregate, *i.e.*, Etaerio.

78. Parthenocarpic fruits are seedless and parthenocarpy can be induced by spraying auxins (hormones).

89. Calyx secrets some nitrogenous substances, which are necessary for post-pollination development of ovary (fruit).

92. Saffron or Kesar is obtained from stigmas and upper part of styles of *Crocus sativus*.

107. Cucurbits are bitter due to presence of tetracyclic triterpenes (Cucurbitacin alkaloid).

171. Fruits of *Biserula* and *Scorpiurus* resemble with catterpillars (mimicry), which are taken by birds by mistake.

184. In Samara and double samara, pericarp forms one ahd two wings respectively.

195. Parthenocarpy (development of fruit without pollination and fertilization) leads to production of seedless fruits.

17

Embryology of Angiosperms

- ☐ Meaning
- ☐ Historical background
- ☐ Flower and its parts
- ☐ Homologies of flower parts
- ☐ Evolution of flower
- ☐ Anther and microsporogenesis
- ☐ Development of male gametophyte
- ☐ Ovule and megasporogenesis
- ☐ Development of female gametophyte or embryo sac in angiosperms
- ☐ Pollination
- ☐ Coevolution of flowers and pollinators
- ☐ Fertilization
- ☐ Endosperm
- ☐ Embryo
- ☐ Formation of seed and fruit
- ☐ Alternation of generations or life history of angiosperms
- ☐ Polyembryony
- ☐ Apomixis
- ☐ Parthenocarpy
- ☐ Experimental or applied embryology

In strict sense, embryology is confined to study of embryo, *i.e.*, **the branch dealing with study of events which lead to the development of embryo** (Embryo is future miny or tiny plant inside the seed) or study of events of life cycle of a plant is called embryology.

- ○ This branch includes study of stamen, carpel, microspore and megaspore formation, development of male and female gametophytes, pollination, fertilization, endosperm formation and embryo formation.

HISTORICAL BACKGROUND

History of this branch also dates back to **Aristotle**, but certainly he did not recognize the sex in plants.

Theophrastus (Third century B.C.) : He has written something about **pollination in date-palm.**

Sex cells in plants were observed after invention of microscope.

N. Grew (1682) : He realized the fact that **stamens are male organs of flower.**

Camerarius (1694) : **Sexuality in plants** was discovered by Camerarius. He reported that anthers are male sex organs and ovary with style and stigma are the female sex organs.

Kolreuter (1761) : Significance of pollination in seed setting and role of insects in pollination was recognized by him. Pollen morphology was also studied by him.

Amici (1824) : Actual role of pollen in fertilization was recognized by this Italian mathematician and astronomer in *Portulaca oleracea*, *i.e.*, **pollen grain bursts on stigma to form pollen tube which pierces through style to reach ovule (pollen tube was discovered by Amici).**

Schleiden : Amici's view was confirmed by Schleiden.

Hofmeister (1849) : He first of all used the term **Alternation of generations.**

Strasburger (1884) : He made most significant discovery of syngamy (true act of fertilization) in *Monotropa*, *i.e.*, **actual fusion of male gamete with female gamete (egg).**

As two male gametes are liberated from pollen tube, he could not recognize the fate of second male gamete.

Nawaschin (1898): He made discovery of **'double fertilization'**, *i.e.*, one male gamete fuses with egg **(syngamy)** to form zygote and second male gamete fuses with 2 polar-nuclei or secondary nucleus **(triple fusion)** to form primary endosperm nucleus.

- Later on double fertilization was found to be a **universal feature of angiosperms.**
- In between 1930–40, India started taking lead in the field of embryology of angiosperms.

Prof. P. Maheshwari was the most important and founder Indian embryologist of international fame (Father of Indian Embryology).

- His book, **'An Introduction to Embryology of** Angiosperms' is an important contribution in the field of embryology.
- Nowadays much emphasis is being given on Experimental embryology (Tissue culture techniques).

E. Hannig (1904) started **embryo culture** technique which was elaborated by **Laibach** (1925).

Guha and Maheshwari (1964) used pollen culture for haploid production in *Datura*.

FLOWER AND ITS PARTS

In angiosperms, the main plant body is **sporophytic** ($2n$) which is differentiated into root, stem and leaves. In reproductive phase, flowers are produced.

- **Flower** is the most important part, which is concerned with sexual reproduction.
- o **Flower is considered to be a modified shoot** (shoot of determinate growth) with highly condensed internodes and leaves are specialized variously to act as different floral parts or organs (like sepals, petals, stamens, carpels, etc.).

A typical flower is having 4 main parts:

1. Calyx

It is outermost whorl of flower and its units are sepals. The sepals are green in colour, having leafy texture. The primary function of calyx is **protection of inner floral parts** during bud condition.

Nowadays it is suggested that some nitrogenous substances are secreted by sepals which are necessary for post-pollination development of ovary.

2. Corolla

Flowers have charm due to bright and showy petals, which collectively form corolla, second whorl of flower. Its function is protection and **helps in pollination** by attracting insects due to attractive colours and curious form.

3. Androecium

It is male reproductive part of flower and its units are **stamens.**

- A stamen is having anther, filament and connective as its parts. **Anther is fertile part** in which microspores or pollens are produced.

4. Gynoecium or Pistil

It is female reproductive part of flower and its units are **carpels.**

- A carpel is having 3 parts– Stigma, style and ovary. Ovary is the most important part in which ovules are borne.
- o **Calyx and Corolla** are **accessory whorls** of flower.
- o **Androecium and Gynoecium** are **necessary or essential whorls** of flower.

HOMOLOGIES OF FLOWER PARTS

Carpel — Megasporophyll
Ovule — Megasporangium
Embryo sac — Female gametophyte
Egg — Female gamete
Stamen — Microsporophyll
Anther (pollen sac) — Microsporangium
Pollen or pollen grain — Microspore
Pollen with pollen tube (or germinating pollen) — Male gametophyte

EVOLUTION OF FLOWER

Flower is actually a sexual display, which enhances the reproductive success of a plant. Flowers help the stationary plants to mate distant members of their own species by attracting animals to transfer pollens from one plant to another and this advantage has allowed the flowering plants to become the dominant terrestrial plants.

- The earliest seed plants were gymnosperms, which are represented mainly by conifers (pines, firs and spruces) nowadays. These plants do not produce flowers but they bear male and female cones. The male cones produce and release a large number of pollen grains in early spring which float about on wind and some of them enter the pollen chambers located on the scales of female cones and here these are caught by sticky coatings of sugars and resins. The pollen grains germinate and pollen tubes reach to the female gametophytes at the base of cone's scale. The sperms or antherozoids are liberated which fertilize the egg within a female gametophyte and begins a new generation.
- Wind pollination is an **inefficient** operation as most of the pollens are lost. If a gymnosperm could attract an animal to carry its pollen from male to female cone, it would greatly enhance its reproductive rate and hence evolutionary success.
- Insects, especially beetles are among the most abundant animals on earth, which exploit every possible food resource, including reproductive parts of gymnosperms. About 150 million years ago, some beetles fed on both the protein-rich pollens of male cones and sugar-rich secretions of female cones. While feeding on pollens, their bodies get dusted with pollens and if the same beetle were to visit the another plant of the same species to feed on sugary secretions of the female cone, some of the loose pollens would quite likely rub off on the female cone. This sets the stage for the evolution of flowering plants from gymnosperms.
- o Efficient pollination by insects requires that a given insect visits many plants of the same species and thus pollinating them along the way. Following two key adaptations were necessary for the plants :

(i) Enough pollens or nectar must be produced within the reproductive structures so that insects regularly visit them to feed.

(ii) The location and richness of these storehouses of pollens and nectar must be advertised to the insects, both to show them where to go and to attract them to specialize on that particular plant species.

Any mutation that contributed to these adaptations would enhance the reproductive success of the plant that carried the mutation and would be favoured by natural selection. **By about 130 million years ago, flowers had evolved with exactly these adaptations.** The advantages of the flowers are so great that flowering plants are dominant in both temperate and tropical zones today and a large number of animals like bees, moths, butterflies, humming birds and even some mammals feed at and pollinate flowers.

- ○ Evolution commonly produces new structures by modifying old ones and **flower parts are actually highly modified leaves, shaped by mutation and natural selection into a form that enhances pollination.**
- Following four evolutionary trends among flowers are evident :

1. From flowers with many parts that are indefinite in number, flowers have evolved towards having few parts that are definite in number.

2. The number of floral whorls has been reduced from four in early flowers to three, two or sometimes one in more advanced ones. The original spiral arrangement of parts is no longer evident with shortening of floral axis. The floral parts often have become fused.

3. The superior ovary has changed into inferior ovary and perianth has been differentiated into distinct calyx and corolla.

4. The regular symmetry (actinomorphy) has been changed into irregular symmetry (zygomorphy).

ANTHER AND MICROSPOROGENESIS

Pollen grains or microspores are formed inside anther, which is the fertile portion of stamen or microsporophyll.

- This formation of microspores or pollens is called **microsporogenesis.**
- Anther is having a column of sterile tissue called connective and on either side of this connective is a anther lobe.
- Each anther lobe is usually having 2 chambers or pollen sacs called **microsporangia** and thus generally there are 4 **microsporangia per anther** (*i.e.,* **tetrasporangiate**).

Such anthers having 2 anther lobes and 4 microsporangia or pollen chambers are called **'dithecous anthers'** or **two celled anthers.** However, at maturity, two microsporangia of an anther lobe get united by dissolution of partition wall between them.

- In some plants (*e.g.,* Malvaceae family), anther is having only single anther lobe and 2 microsporangia instead of 4. Such anthers are called **'monothecous anthers'** or **one celled anthers.**
- A rare case is in *Arceuthobium,* where there is only one microsporangium per anther, *i.e.,* monosporangiate condition.

Detailed structure of anther in a T.S. shows the following structure:

(a) Parietal layers or wall layers of anther.

(b) Pollen chambers or microsporangia having sporogenous tissue or archesporial tissue.

(A) Parietal layers or wall layers

From outside to inner side, following layers are present in wall of anther:

(i) Epidermis : It is single celled thick outer most layer, which is greatly stretched and flattened at maturity. It performs usual **protection** function.

- ○ In *Arceuthobium,* **fibrous thickenings** are present in epidermis, which is now called **exothecium** (which is characteristic of gymnosperms).

(ii) Endothecium : Inner to epidermis is single layered endothecium. The cells of endothecium are **tangentially elongated** and are having **fibrous thickenings** arising from their inner walls. These fibrous thickenings are of cellulose and are **hygroscopic** in nature and thus **help in dehiscence** of anther. The cells from where dehiscence occurs are having thin cell walls and collectively constitute **stomium** (*i.e.,* dehiscence occurs through stomium).

- ○ In family Hydrocharitaceae, fibrous thickenings are absent.

(iii) Middle layers : Inner to endothecium are middle layers, which are variable, *i.e.,* 1–4 or absent.

- In *Helopteia*—3 to 4 middle layers are present.
- In Najadaceae and Lamnaceae—Middle layers absent.
- Disintegration of these middle layers usually occurs at maturity.

(iv) Tapetum : This is the **innermost parietal layer.** The cells of this layer are having **large nuclei** and **dense cytoplasm.**

- This layer is of great physiological importance as most of the food material from outside passes through this layer. At maturity, these cells degenerate and **provide nourishment** to developing microspores or pollens inside.
- DNA content is **enormously increased** in tapetal cells due to:

(a) Multinucleate condition.

(b) Endomitosis : Chromosome duplication and separation of chromatids take place without spindle formation inside the intact nuclear membrane, *i.e.,* large polyploid nucleus is formed. So tapetal cells are **polyploid.**

(c) Polyteny : Increase in number of chremonemata per chromosome.

(d) Restitution nuclei : Upto anaphase, normal mitosis occurs, but two sets of chromosomes thus formed are present in a common nuclear membrane. Such nuclei are called restitution nuclei.

Tapetum is of two types:

(1) **Amoeboid or plasmodial tapetum :** Inner and radial walls breakdown at early stage and these cells are free in microsporangia or pollen chambers.

(2) **Secretory or glandular tapetum :** This is more common type of tapetum, which remains as such throughout.

- Tapetum is the layer, which secrets both enzymes and **substances of hormonal nature.**
- The main function of tapetum is to provide nutrition to pollens but it also secrets some substances of utmost importance like:

(a) **Callase enzyme :** Tapetum secrete callase enzyme which **dissolves callose** substances by which 4 pollens of a pollen tetrad are united, hence separating microspores or pollens of a tetrad.

(b) **Ubisch bodies :** These bodies of lipid nature are also secreted by tapetum. Ubisch bodies get covered with sporopollenin and thus increase thickness of exine (*i.e.*, outer layer of pollen wall). Ubisch bodies are spheroidal and have diameter of only few microns (μ). These are produced only by glandular tapetum (not by amoeboid tapetum).

(c) **Pollen kitt substances :** Pollen kitt is outer most oily, thick, viscous, sticky, electron dense homogeneous coating of pollen grains of many **entomophilous** plants (*i.e.*, insect pollinated plants).

o Pollen kitt is chiefly composed of **lipids and carotenoids.**

o These **pollen kitt substances are secreted by tapetum.** Main functions of pollen kitt are:

(i) Due to sticky nature of pollen kitt, the pollens get attached to bodies of insects.

(ii) It also acts as **insect attractant.**

(iii) It protects pollens against harmful UV-rays.

(B) Pollen chambers or Microsporangia

Inside the wall layers, microsporangia or pollen chambers (4 or 2) are there in which **sporogenous tissue or archesporial tissue** is present, which give rise to microspores or pollens through process of **microsporogenesis.**

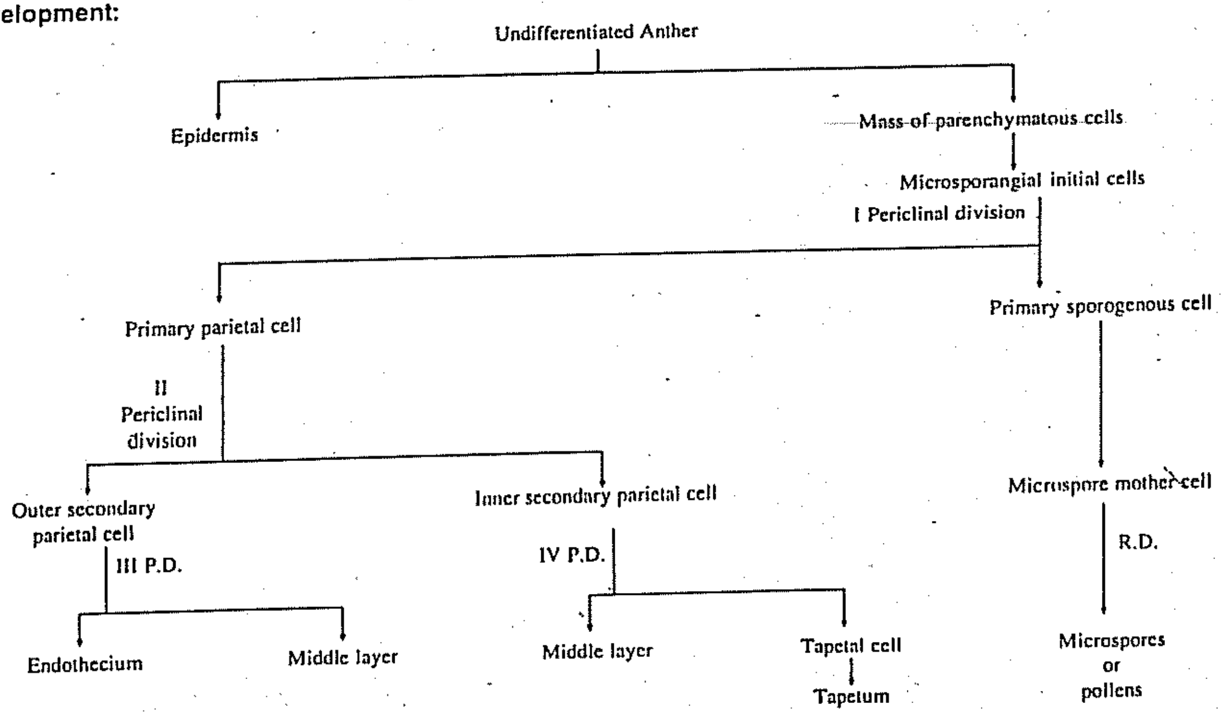
Microsporogenesis

Primary sporogenous cell gives rise to **microspore mother cells or pollen mother cells** (MMC or PMC). Each MMC on reduction division gives rise to 4 microspores or pollens and this formation of microspores or pollens is called microsporogenesis.

- Here **karyokinesis** (nuclear division) is followed by **cytokinesis** (wall formation). Cytokinesis is of two types:

1. **Successive type :** This type of cytokinesis is common **in monocots.** Here both **meiotic I and II** nuclear divisions are followed by wall formation and it leads to **'isobilateral tetrad'.** Further wall formation is **centrifugal** here (*i.e.*, from centre to periphery).

Development:


Undifferentiated Anther
Epidermis
Mass of parenchymatous cells
Microsporangial initial cells
I Periclinal division
Primary parietal cell
Primary sporogenous cell
II Periclinal division
Outer secondary parietal cell
Inner secondary parietal cell
Microspore mother cell
III P.D.
IV P.D.
R.D.
Endothecium
Middle layer
Middle layer
Tapetal cell
Tapetum
Microspores or pollens

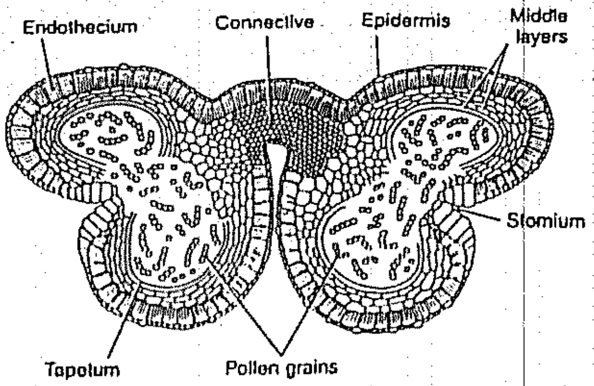


Fig. 17.1. T.S. of a mature anther

2. Simultaneous type : This type of cytokinesis is common in **dicots**. Here I nuclear division is not followed by wall formation (dyad not formed) and wall formation occurs simultaneously after II nuclear divison. This type of cytokinesis leads to formation of **tetrahedral tetrad.** Further wall formation is **centripetal** here (*i.e.*, from periphery towards centre).

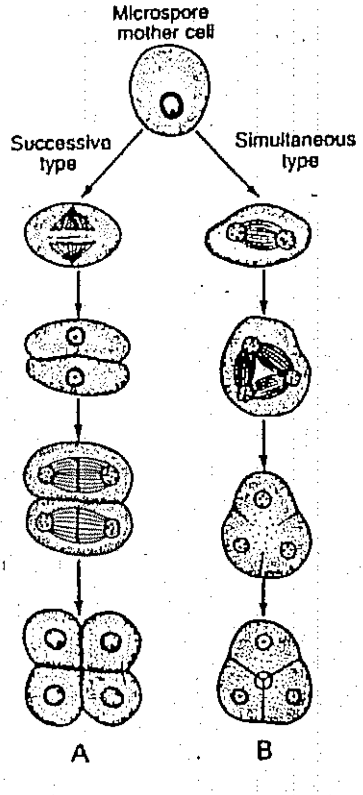


Fig. 17.2. Two types of cytokinesis (simultaneous and successive type) in microsporogenesis

- Besides tetrahedral and isobilateral pollen tetrads, some other types of tetrads are : **Linear tetrad,** *e.g., Halophila* (Fam. Hydrocharitaceae), **T-shaped tetrad,** *e.g., Aristolochia* and *Butomopsis,* **Decussate tetrad,** *e.g., Magnolia.*
- But tetrahedral tetrad of microspores or pollens is **most common** in angiosperms.
- In *Aristolochia elegans*, all five types of tetrads are found.

Abnormal feature is present in development of pollens in family Cypraceae (Sedges), *e.g., Cyperus.* Here only one nucleus remains functional after meiotic division of MMC or PMC (3 degenerate). So only one microspore or pollen is formed from a single MMC or PMC.

- Usually 4 microspores or pollens of a tetrad separate from one another soon after meiosis, but some **exceptions** are there, *e.g.*,

(a) In some cases like *Juncus, Typha, Elodea, Drimys, Drosera,* etc., 4 pollens do not separate and remain in tetrads. Such pollens are called **compound pollens** or microspores or pollen grains.

(b) In *Neottia* (orchid) : Compound pollens are held together in small units called **'massullae'.**

(c) In family **Mimosaceae,** intermediate condition is present, *i.e.*, **8 – 64 pollens are present in group.**

(d) In many members of **Asclepiadaceae** and **Orchidaceae,** all the pollens of an anther lobe are packed in bag like structure called **'Pollinium'** (which along with sticky corpusculum and thread like retinaculi form **'Translator apparatus'**).

(e) In rare cases, there is occurrence of **more than four spores** in a pollen tetrad, which is called **'polyspory'. This** phenomenon has been reported in *Hyphaene* and *Cuscuta reflexa.*

- ○ Pollen tetrads with 11 microspores or pollens have been reported in *Cuscuta reflexa.*

Dehiscence of anther

Of different types:

(i) **Longitudinal dehiscence,** *i.e.*, by longitudinal slits, *e.g.*, in *Datura, Gossypium, Hibiscus,* etc.

(ii) **Transverse dehiscence,** *e.g., Ocimum sanctum*

(iii) **Porous dehiscence** or by apical pores, *e.g., Solanum*

(iv) **Valvular dehiscence,** *e.g., Berberis*

Structure of microspore or pollen or pollen grain

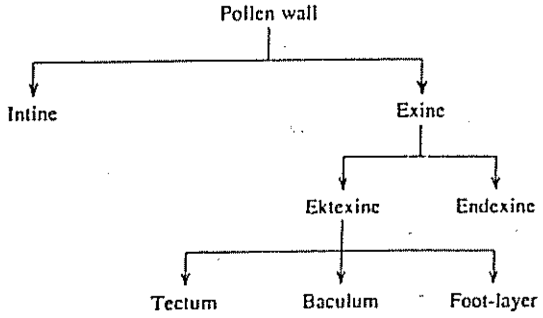
Pollen grains or microspores are **male reproductive bodies** of a flower. Each microspore or pollen is a unicellular, uninucleate (haploid), **oval or rounded structure.** (In *Zostera,* pollens are filiform having length upto 2000 µ).

Size : General size of pollens is **10 – 200 µ.**

- **Smallest pollens** are present in *Myosotis* (10 µ) and **largest pollens** are present in some members of **Cucurbitaceae** and **Nyctaginaceae** (*Mirabilis*—250 µ).
- Each microspore or pollen is having a two layered wall. Outer layer is thick, tough, cuticularized called **exine,** which is chiefly composed of a material (derived from carotenoids) called **'sporopollenin'.** It is highly

resistant to biological and physical decomposition, due to which pollens are preserved for a long time in fossils. Sculpturing of exine is of great taxonomic significance. Inner layer is thin, delicate and smooth called **intine**, which is made of '**pectocellulose**'.

- Terms **Intine** and exine were given by **Fritsche** (1837).



- Exine is not uniform but is thin at one or more places. These thin-walled places in exine are called **germ pores** (1 or more). Through these germ pores, intine comes out in the form of pollen tube.
- **Ubisch bodies** secreted by tapetum help in external thickening of exine as these bodies get coated with sporopollenin.
- In pollens of some **insect-pollinated plants**, outermost layer of pollen wall is **pollen kitt**, secreted by tapetum (already explained).

Chemical composition : Microspore or pollen is having following chemical components:

Carbohydrates	—	24–48%
Proteins	—	7–26%
Water	—	7–16%
Fats	—	0.9–14.5%
Ash	—	0.9–5.4%

Some other important points to remember

- Study of pollen grains or microspores is called **palynology**, a term given by **Hyde and Williams** (P.K.K. Nair— famous Indian palynologist).

Palynology is having following sub-branches :

(a) **Geopalynology :** Study of fossil pollen grains.

- Pollens are used in finding age of rocks.

(b) **Aeropalynology :** Study of pollens found in air or atmosphere.

- Pollens present in air cause different types of allergies like hay fever and asthama and are called **aeroallergens.**

(Pollens of *Ambrosia* of family Compositae cause hay fever).

- Important aeroallergens in india are pollens of *Amaranthus, Artemisia, Chenopodium album, Prosopis juliflora* and *Ricinus communis*, etc.

(c) **Iatropalynology :** Study of pollens in criminology and medical aspects.

- Place of crime can be judged by study of microspores or pollens collected from dirt under shoes, clothes and nails, etc.

(d) **Melittopalynology :** Study of pollens in honey.

- Honey bees utilize pollens of *Eugenia, Sapindus, Putranjiva, Citrus, Heloptein*, etc., in honey formation.

○ Pollens of *Serjania lethalis* (fam. Sapindaceae) are poisonous and poisonous honey contaminated with these pollens caused a large number of deaths in Brazil.

DEVELOPMENT OF MALE GAMETOPHYTE OR MICROGAMETOGENESIS

- Microspore or pollen is the beginning (or first cell) of male gametophytic generation.
- Development of male gametophyte or microgametophyte is uniform in all angiosperms. Here, the microspore undergoes only two **mitotic divisions** and thus fully developed male gametophyte in angiosperms is very very simple and reduced, *i.e.*, only **3-nucleated structure** and is dependent upon sporophyte.
- In **tropical** plants, the microspore nucleus divides immediately without any resting period but in **temperate plants** (colder regions plants), there is a resting period from few days to several weeks.
- Recently formed microspore is having dense cytoplasm without vacuoles and a centrally located haploid nucleus. As it matures, many small vacuoles develop in this cytoplasm which unite to form a large central vacuole, due to which nucleus is pushed to one side. Nucleus of microspore now divides mitotically into two nuclei, one is larger called **vegetative or tube nucleus** and second is smaller called **generative nucleus.** These two nuclei are now separated by wall and thus **2 cells** are now formed in a microspore, *i.e.*, **smaller generative cell and larger vegetative cell.**

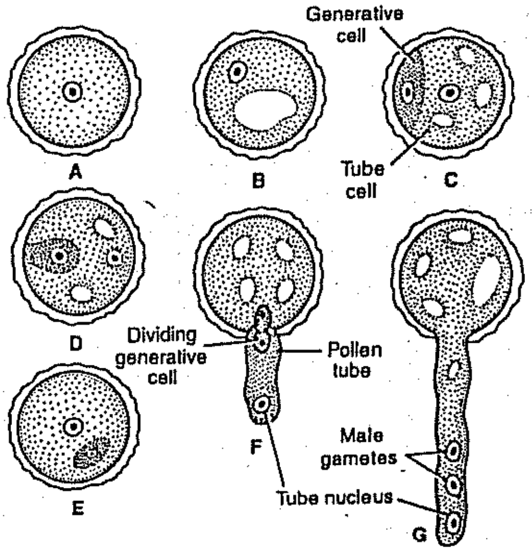


Fig. 17.3. A–G. Stages in development of male gametophyte in angiosperms

- The microspore or pollen is shed from anther at this two celled stage, *i.e.*, **pollination occurs at 2-celled stage of pollen.** Further development of male gametophyte occurs on stigma after pollination (So development of male gametophyte is completed to a great extent *in situ*, *i.e.*, inside anther). The **smaller generative cell** now separates from the wall and becomes spindle-shaped, which now lies freely in larger vegetative cell. The spindle-shaped generative cell divides into **two male gametes.**

Now at stigma, the microspore swells up, thick exine ruptures and intine comes out through germ pore. This pollen tube pierces through stylar tissue and is having vegetative or tube nucleus at its tip and 2 male gametes behind the tube nucleus.

- **This pollen with pollen tube** (having 3 nuclei) is fully developed male gametophyte or microgametophyte in angiosperms.

Abnormal feature : Nemec (1898) reported pollen grain embryo sac (or male gametophyte like female gametophyte or embryo sac) in *Hyacinthus* (fam. **Liliaceae**), which is called **'Nemec phenomenon.'**

OVULE (MEGASPORANGIUM) AND MEGASPOROGENESIS

Gynoecium or pistil is the female reproductive part of flower and carpel is the unit of gynoecium. Morphologically, carpel is considered to be **modified leaf** bearing ovules or megasporangia. Thus carpel is also known as **megasporophyll.** A carpel is having **stigma, style and ovary,** as its 3 parts. Ovary is the basal swollen portion of carpel which bears one or more rounded or oval structures called **ovules or megasporangia.**

(Ovary at maturity forms **fruit** and ovule forms **seed**).

Ovule or Megasporangium

Inside the ovary, there is present either a single ovule at its base or many ovules on its sides.

- Arrangement of ovules inside the ovary is called **placentation.**
- The ovule is attached to placenta by means of a stalk called **funicle or funiculus.**
- The point of attachment of funiculus to the body of ovule is called **hilum.**
- The main body of ovule is made of parenchymatous tissue called **nucellus or megasporangium-proper.**
- Nucellus is covered on its outerside by one or two coverings called **integuments** and hence ovule is rightly called as **integumented-megasporangium (Indehiscent).**
- Ovule having single integument is known as **unitegmic ovule** (*e.g.*, in **gamopetalae**) and ovule having two integuments is called **bitegmic ovule** (*e.g.*, in polypetalae of dicots and monocots).

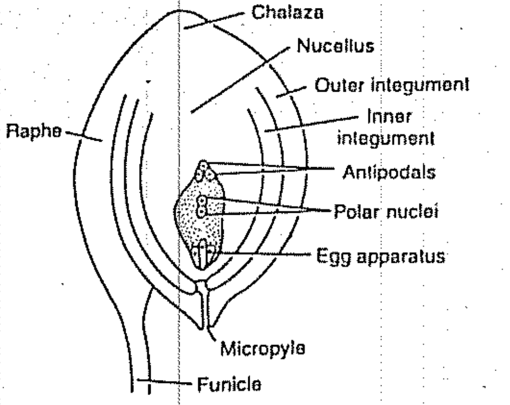


Fig. 17.4. Structure of a typical ovule of angiosperms

(**Bitegmic ovules** are more common in angiosperms and have been found in 208 families).

- When there are 2 integuments, **inner one is formed first.**
- The integuments cover entire nucellus except a small pore at upper end, which is called **micropyle.** Micropyle is formed generally by inner integument or by both integument.
- In some cases, there is **no integument** in ovule and such ovule without integuments is called **ategmic ovule,** *e.g.*, in *Santalum, Loranthus, Liriosma, Olax*, etc.
- The place of junction of integuments and nucellus is called **chalaza.**
- In **inverted ovules** (most common type), the stalk or funiculus is attached to the main body of ovule for some distance to form a ridge like structure, called **raphe.**
- In the nucellus of ovule, a large oval cell is present at micropylar end, which is known as **embryo sac** (female gametophyte), developing from megaspore.

Some other specific structures associated with ovule

(a) Endothelium : In some unitegmic ovules, the nucellus degenerates at very early stage and then inner most layer of integument becomes specialized, *i.e.*, cells become radially elongated, polyploid, full of starch and fats. This specialized layer of cells is called **endothelium** and it **provides nutrition to embryo sac.** It is generally single layered but 10–12 layered endothelium is present in family Compositae.

- **Endothelium** in ovule is similar to tapetum of anther in function, hence it is also called **Integumentary tapetum.** It is present in 65 families of dicots.

(b) Obturator : Any ovular structure which directs the growth of pollen tube towards micropyle of ovule is called obturator. It acts as a type of **bridge** for pollen tube.

- Obturator secrets surface exudate for nutrition of pollen tube and also provides mechanical and chemical guidance to pollen tube. It shrinks after act of fertilization.
- Obturator develops from **funiculus** or **placenta.**

(c) **Nucellar beak :** In rare cases, nucellus comes out in the form of a beak like structure through micropyle of ovule, which is called nucellar beak.

- Nucellar beak is found in Euphorbiaceae, Cucurbitaceae and Polygonaceae.

(d) **Perisperm :** Generally till maturity, whole of the nucellus is consumed in seeds but in some cases, a **thin layer** of nucellus is present in mature seeds, which is called perisperm (*i.e.*, Perisperm is remnant of nucellus).

- ○ Seeds having perisperm are called **perispermic seeds**, *e.g.*, *Mirabilis jalapa* (4 O'clock plant), *Nymphaea, Zingiber, Portulaca, Canna, Capparis*, etc.

(e) **Hypostase :** Group of lignified cells below embryo sac in nucellus is called hypostase.

- Van Tieghem (1901) first of all coined this term.
- Hypostase prevents sinking of embryo sac into the base and also maintains water balance.
- Hypostase is found in families like Amaryllidaceae, Liliaceae, Euphorbiaceae and Zingiberaceae.

(f) **Aril or third integument :** In some cases, there is **a collar like outgrowth from the base of ovule forming a kind of third integument called aril.**

- Aril is found in *Asphodelus, Trianthema, Litchi, Myristica* (Nutmeg), *Pithecolobium* (Ingadulce) and *Ulmus.*
- (In *Ulmus*, it is formed by splitting of outer integument).
- (In litchi, aril forms edible part in fruit).

(g) **Caruncle :** It is an outgrowth on one end of ovule (seed) of *Ricinus communis* (castor) of family **Euphorbiaceae.**

- Caruncle is formed by **proliferation of cells of outer integument in micropylar region.** Its function is to absorb water during seed germination.

(h) In some plants of family **Cactaceae**, in between two integuments, a **prominent air space** is present at chalazal end.

(i) Stomata are absent in integuments of ovules, but **stomata on outer integument** are present in *Cleome, Gossypium* and *Magnolia.*

(j) **Stomata** and **chlorophyll**, both are present in integuments of *Hymenocallis occidentalis, Lilium, Gladiolus cammunis* and *Amaryllis belladona.*

Types of ovules

Depending upon position of micropyle in relation to chalaza and funiculus, ovules are of **6 types** in angiosperms:

1. Orthotropous or Atropous or Straight : This is the **most primitive and simplest type of ovules in angiosperms.**

- This is erect (*i.e.*, micropyle at upper end) and here micropyle, chalaza and funiculus are in the same **straight line**, *e.g.*, in **Polygonaceae and Piperaceae.**

2. Anatropous or Inverted : This is the most common type of ovule found in angiosperms (*i.e.*, in 82% families).

Here body of the ovule gets inverted and micropyle is on lower side. Further micropyle and funiculus lie side by side and micropyle is close to hilum.

3. Hemianatropous or Hemitropous : Here nucellus and integuments (*i.e.*, body of ovule) is at right angles to stalk or funiculus, *e.g.*, in Primulaceae and *Ranunculus.*

4. Campylotropous : Here the body of the ovule gets curved and micropyle is directed downwards. Further, micropyle is not in line with chalaza, *e.g.*, in Capparidaceae, Chenopodiaceae and Cruciferae, etc.

5. Amphitropous (*Amphi*-both) **:** Here curvature is observed both in the body of ovule and embryo sac. The embryo sac assumes horse shoe-shape. Micropyle is again directed downwards, *e.g.*, in families Papaveraceae, Alismaceae and Butomaceae, etc.

6. Circinotropous : This is characteristic type of ovule found in family Cactaceae, *e.g.*, *Opuntia*. Here the ovule is straight first, due to more growth on one side the ovule gets inverted, but this unilateral growth still continues till the ovule becomes straight again. In this manner, the funiculus takes a complete round around the body of ovule.

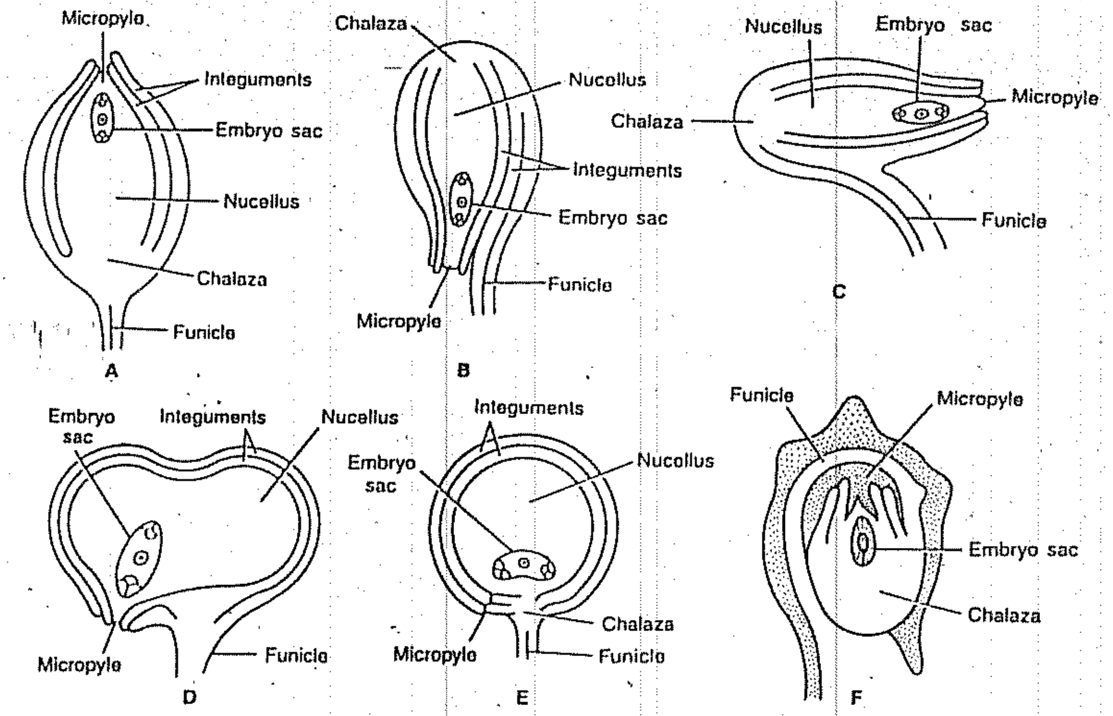
Megasporogenesis

Formation of megaspores (n) from megaspore mother cell ($2n$) inside the megasporangium (ovule) is called megasporogenesis.

- A single hypodermal cell in nucellus is differentiated from rest of the cell by its dense cytoplasm, larger size and larger nucleus, which is called **primary archesporial cell or archesporial initial.**
- **In sympetalae** or gamopetalae with unitegmic ovules, the **primary archesporial cell** or archesporial initial directly acts as **megaspore mother cell.** So here megaspore mother cell or sporogenous cell is **hypodermal** in position and there is **no parietal layer** (nucellar tissue) between nucellar epidermis and megaspore mother cell. Such type of ovules are called **tenuinucellate ovules** (Nucellar tissue less developed).
- **In polypetalae with bitegmic ovules, the primary archesporial cell or archesporial initial divides periclinally to form outer parietal cell and inner sporogenous cell or megaspore mother cell. The outer parietal cell** by further periclinal divisions gives rise to **many parietal layers of nucellar tissue** between nucellar epidermis and megaspore mother cell. Such ovules are called **crassinucellate ovules** (nucellus tissue much developed).
- **The megaspore mother cell** ($2n$) undergoes reduction division (meiosis) to form **linear tetrad of 4 haploid megaspores** (megasporogenesis).
- Generally, **3 megaspores towards micropylar end degenerate and 4th towards chalazal end remains,** is **functional megaspore,** which develops into **embryo sac or female gametophyte.**

(In *Casuarina*, all or any one of 4 megaspores may become functional).

- In some cases like *Orchis maculata, Rumex*, etc., **T-shaped tetrad** of megaspores is produced.
- Isobilateral and tetrahedral tetrads of megaspores are rare.


Micropyle
Integuments
Embryo sac
Nucellus
Chalaza
Funicle
A
Chalaza
Nucellus
Integuments
Embryo sac
Funicle
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B
Nucellus
Embryo sac
Micropyle
Chalaza
Funicle
C
Embryo sac
Integuments
Nucellus
Micropyle
Funicle
D
Integuments
Embryo sac
Nucellus
Chalaza
Micropyle
Funicle
E
Funicle
Micropyle
Embryo sac
Chalaza
F

Fig. 17.5. Different types of ovules found in angiosperms A. Orthotropous B. Anatropous C. Hemianatropous D. Campylotropous E. Amphitropous F. Circinotropous

DEVELOPMENT OF FEMALE GAMETOPHYTE OR EMBRYO SAC IN ANGIOSPERMS (MEGAGAMETOGENESIS)

Megaspore is the initial cell or beginning of female gametophyte or embryo sac. The nucleus of megaspore undergoes divisions and give rise to embryo sac or female gametophyte, which is called **megagametogenesis.**

- In angiosperms, **female gametophyte** is also **reduced** like male gametophyte and is **dependent upon sporophytic tissue.**
- On the basis of number of megaspore nuclei taking part in development of female gametophyte or embryo sac, there are 3 types of embryo sacs:

1. **Monosporic type :** Here **only one** of four megaspore nuclei formed after R.D. of megaspore mother cell, **takes** part in development of embryo sac.

2. **Bisporic type :** Here **two** out of four megaspore nuclei take part in development.

3. **Tetrasporic type :** Here **all the four** megaspore nuclei take part in development of embryo sac.

1. Monosporic type of embryo sac

(A) Polygonum type : This is the **most common type** of embryo sac in angiosperms, hence is **normal type of development** (found in about 70% cases).

- It is called **Polygonum type** because it was first reported by **Strasburger** (1879) in *Polygonum.*
- It develops from **single chalazal megaspore of megaspores tetrad.**

During development, the single nucleus of functional megaspore (of chalazal end) undergoes **3 mitotic divisions** to form **8 nuclei.** Out of these 8 nuclei, 4 are present at micropylar end and 4 at chalazal end. One nucleus from each group comes in centre to form **2 polar nuclei.** Remaining 3 nuclei at micropylar end constitute **egg apparatus** and remaining 3 nuclei at chalazal end constitute 3 antipodal cells or **antipodals.**

- So fully developed normal type of female gametophyte or embryo sac in **8–nucleated** and **7-celled** structure, *i.e.*, **egg apparatus at micropylar** end is having 3 cells (2 synergids + 1 egg cell), **3 antipodal cells at chalazal** end and **a central cell having two polar nuclei in centre.**

(a) Egg apparatus : Made of 2 synergids and 1 egg cell at micropylar end of embryo sac.

(i) Synergids or helping cells : 2 synergids are present side by side and they partly cover the egg cell.

- A prominent structure called **filiform apparatus** (in the form of **finger like projections** from cell wall) is present in upper part of each synergid.
- Synergids are **short-lived** (one of them degenerates long before fertilization and second after entry of pollen tube into embryo sac).

- These synergids help in growth of pollen tube towards egg by secreting chemotropically active substances. The synergids also help in nutrition of embryo sac by absorption and transport of food from nucellus through their filiform apparatus.
- The cytoplasm of synergids is strongly polarized.

(ii) **Egg cell :** Egg is the constant feature of embryo sac. It fuses with one male gamete to form zygote (Syngamy) and hence embryo.

(b) **Central cell :** A larger cell is present in the centre of embryo sac having 2 polar nuclei (one from micropylar end and other from chalazal end).

- These 2 polar nuclei before fertilization generally fuse to form a secondary nucleus ($2n$) or definitive nucleus.
- Secondary nucleus or 2 polar nuclei fuse with second male gamete (of pollen tube) to form **primary endosperm nucleus (triple fusion)** and hence **endosperm.**

(c) **Antipodals :** 3 antipodals are present at chalazal end of embryo sac. In some cases, number of antipodals increases very much, *e.g.*, in *Sasa paniculata* (a bamboo), 300 antipodals are present. (Fig. 17.6)

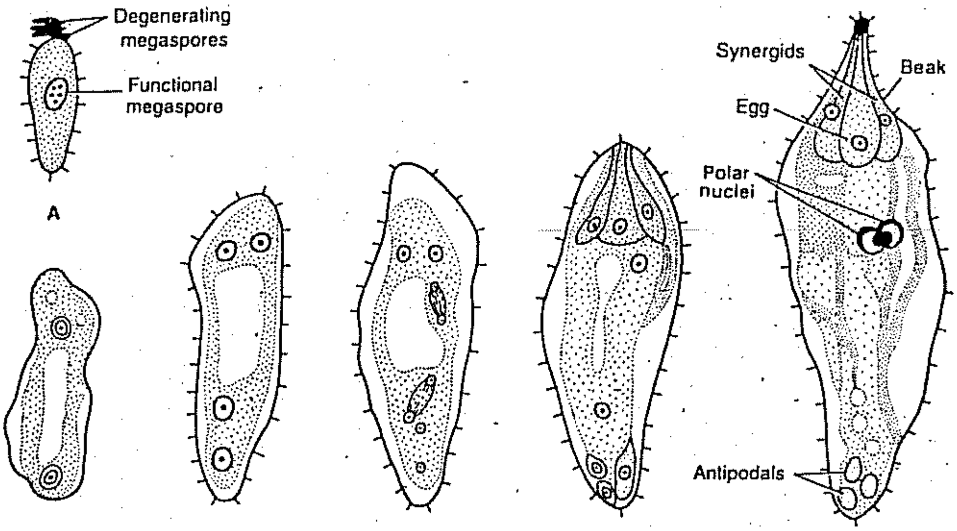

Fig. 17.6. A–F. Stages in development of *Polygonum* type (most common type) of embryo sac or female gametophyte in angiosperms

- These are short-lived and are considered to be vegetative tissue of embryo sac.
- The antipodals perform **nutritive** role for developing endosperm and embryo.

(B) **Oenothera type :** This type of monosporic embryo sac develops from single functional megaspore of micropylar end (not chalazal). Further it is **4-nucleated** (not 8-nucleated) having **egg apparatus and a single polar nucleus** in centre (antipodals absent). This type of embryo sac development is found in family–**Onagraceae.**

2. Bisporic type of embryo sac

- Also called **Allium** type. Here embryo sac develops from **2 megaspore nuclei** out of 4 nuclei formed after R.D. of megaspore mother cell.
- This is again 8-nucleated and 7-celled (as in normal type).

3. Tetrasporic type of embryo sac

Here **all the 4 megaspore nuclei** formed after R.D. of megaspore mother cell are functional and take part in development of embryo sac.

It is further of different types :

(a) **Pepromea type : 16 nucleated with egg apparatus** (1 synergid + 1 egg cell), **8 polar nuclei and 6 antipodals.**

(b) **Penea type : 16 nucleated with egg apparatus** (2 synergids + 1 egg cell), **4 polar nuclei, 3 antipodals** and two groups of 3 cells each on sides.

(c) **Fritillaria type :** Having **egg apparatus** (2 synergids + 1 egg cell), 4 n **secondary nucleus** (1 triploid nucleus + 1 haploid nucleus), **3 triploid antipodals.**

(d) **Plumbigella type :** Having **only 1 egg cell at micropylar end,** 4 n **secondary nucleus** (1 triploid nucleus + 1 haploid nucleus) in centre, **1 triploid antipodal** at chalazal end.

(e) **Plumbago type : 8 nucleated with 1 egg cell, 4 polar nuclei, 1 antipodal** and one cell on either side.

(f) **Adoxa type : 8 nucleated,** structure **just like normal type.**

POLLINATION

Pollination occurs before fertilization in angiosperms.

- The phenomenon of **transfer of pollens from anther to stigma** of the same or different flower (on same or different plant) is known as pollination.
- This process of pollination occurs only in gymnosperms and angiosperms.
- Pollination in angiosperms generally takes place at 2-celled stage (rarely 3-celled) of microspores or pollens, *i.e.*, vegetative cell and generative cell.

On the basis of destination of pollen grains, pollination is of following 3 types:

1. Self pollination or autogamy

When pollen grains are transferred from anther to stigma of the same flower, it is called autogamy.

- It occurs always in crops with **bisexual flowers**, *e.g.*, wheat, barley, etc.

3 main and essential conditions favouring autogamy are:

(i) Bisexuality : *i.e.*, flower should be having both male and female reproductive parts in it.

(ii) Homogamy : When both male (anthers) and female (stigma) reproductive parts of a bisexual flower mature at the same time, it is called homogamy, *e.g.*, in wheat, rice, potato, etc.

(iii) Cleistogamy : This is most important adaptation of flower which helps in autogamy. The flowers **which never open** or which never expose their sex organs to environment are called cleistogamous flowers and this phenomenon is called cleistogamy.

(On other hand, flowers which open and expose their sex-organs are called **chasmogamous** flowers).

- Self pollination is a rule in cleistogamous flowers.
- Cleistogamy occurs in *Viola mirabilis*, *Oxalis acetocela*, etc.
- Interesting example is provided by *Commelina benghalensis* (Kankauoa), where on the same plant, both cleistogamous and chasmogamous flowers are found. **Aerial flowers** in *Commelina* are chasmogamous, coloured brightly and are cross pollinated by insects, whereas **underground flowers** on rhizome are cleistogamous, dull in colour and are self-pollinated.

Example of self-pollinated (autogamous) crops : Barley, beans, gram, oats, moong, peas, brinjal, tomato, potato, tobacco, groundnut, til, etc.

2. Geitonogamy

Transfer of pollens from anthers to stigma of the another flower on same plant is called geitonogamy.

- ○ Genetically geitonogamy is equivalent to self-pollination.

(So **autogamy** and **geitonogamy** are types of self-pollination).

e.g., in **maize.**

3. Cross-pollination or allogamy

When the pollens are transferred from anther to stigma of different flower on different plant, it is called cross-pollination or allogamy.

- It is also called **'xenogamy'.**
- Cross-pollination is **a rule in unisexual flowers** but it also occurs in a large number of bisexual flowers.

The main reasons or **adaptations** (contrivances) for **cross-pollination** in bisexual flowers are:

(i) Unisexuality or Dicliny : Two types of unisexual flowers are present, *i.e.*, **staminate** or **male flowers** (having only stamens) and **pistillate** or **female flowers** (having only carpels).

- When flowers are **unisexual**, then two **conditions of plants** are present:

  (a) Monoecious plant : Plant bearing both types of unisexual flowers, *i.e.*, **staminate** as well as **pistillate**, is called monoecious, *e.g.*, maize, castor, coconut, banana, mango, cucumber, grapes, etc.

  (b) Dioecious plants : When two types of unisexual flowers are present on two different plants, this condition is called dioecious.
- Here the male plant bears **staminate flowers**, and **female plant** bears **pistillate flowers**, *e.g.*, papaya, hemp, asparagus, date palm, spinach, etc.
- **Cross-pollination** is a rule in **dioecious plants**, whereas cross-pollination or self-pollination may be in monoecious plants.

(ii) Dichogamy : This is the condition of bisexual flower in which male and female reproductive parts **mature at different times.**

Dichogamy is further of 2 types:

(a) Protogyny : Condition in which female reproductive part (gynoecium) matures earlier, *e.g.*, in bajra, *Aristolochia*, etc.

(b) Protandry : Condition in which male reproductive part (androecium) matures first, *e.g.*, in cotton, marigold, *Impatiens*, *Saxifraga*, etc.

(iii) Herkogamy : When some physical berrier is present between male and female reproductive parts of a flower, which prevent **self-pollination,** is called herkogamy, *e.g.*, in *Calotropis*, **gynostegium** disc is such berrier.

(iv) Heterostyly : Condition in which styles and filaments are of different heights, is called heterostyly. This results in cross pollination, *e.g.*, in **Primrose** (*Primula vulgaris*).

(v) Self sterility or Self-incompatibility : When inspite of viable pollens, they are unable to germinate on the stigma of same flower, is called self-incompatibility and this leads to cross-pollination, *e.g.*, in radish, *Petunia axillaris*, etc.

Agencies behind cross-pollination (allogamy)

Cross-pollination is favoured by nature (as it leads to **hybrid vigour** or superiority) and various natural agencies involved in allogamy are as :

(i) **Wind :** Pollination by wind is called **anemophily** and such plants in which pollination occurs by wind are called **anemophilous plants.**

- **Anemophilous plants** are characterized by small **flowers,** pollens present in large number which are small, dry and light in weight (carried upto 1300 Km by wind), number of ovules generally reduced in ovary (biological significance), feathery or brushy **stigma** (to receive the pollen).
- **Grasses and palms** are generally anemophilous.

(ii) **Water :** Pollination by water is called **hydrophily.**

- **Important hydrophilous plants** are *Ceratophyllum, Vallisnaria, Najas, Zostera,* etc.
- In *Ceratophyllum, Najas* and *Zostera,* pollination occurs **inside water (called Hyphydrophily).** On the other hand, in *Vallisneria spiralis,* pollination occurs **outside water (called Ephydrophily).** *Vallisneria* (submerged hydrophyte) is dioecious plant and both male and female flowers are developed under water on male and female plants respectively. At maturity, male flowers are detached from plant and float on surface of water. The female flowers also come out on surface of water (due to elongation of thin, elongated stalks) at the time of pollination. The female flowers are initially vertical in position but due to more elongation of stalks, they assume horizontal position. The male flowers floating on water surface come in contact with female flowers and thus pollination occurs on surface of water. The pollinated female flowers again go inside water (due to spiral coiling and tightening of stalks) and fruits mature under water.

(iii) **Insects :** Pollination by insects is called **entomophily.**

- Main insects behind pollination are– **bees, flies, wasps, beetles and moths,** which are attracted by colour, odour and nectar.
- Out of these insects, moths carry out pollination in **nocturnal flowers** (which open during night) and rest **of the insects in diurnal flowers** (which open during day time).
- **Bees** alone carry out pollination in 80% cases. These are colourblind for red and are attracted towards yellow, violet or purple colours.
- **Nocturnal flowers are dull in colour and highly fragrant.** Due to heavy fragrance, moths are attracted at night for pollination (Diurnal flowers are variously coloured).
- In *Salvia* (Sage plant), a member of family Labiatae, pollination occurs by **bees** and there is a special **mechanism called 'Turn pipe mechanism' or 'Lever mechanism'** of pollination.
- **'Fly trap mechanism'** of pollination occurs in *Aristolochia.* Flies are attracted by foul-rotten tobacco like odour.
- **'Trap door mechanism'** of pollination occurs in *Ficus* species (having **hypanthodium** inflorescence).
- In an orchid *Ophrys speculum,* there is **most interesting and unique** mechanism of pollination. Here pollination occurs by a wasp called *Colpa aurea.* In this orchid, pollination occurs by **act of pseudo-copulation.** The appearance and odour of *Ophrys* is similar to female wasp and hence male wasps are mistaken and they land on *Ophrys* flowers to perform act of pseudo-copulation and thus pollination takes place. This plant-insect relationship is useful only to plant.
- In *Yucca,* pollination occurs by a moth called *Tageticula.* This pollination mechanism is example of extreme specialization in nature. There is **obligate symbiotic relationship** between *Yucca* and moth, *Tageticula* (*i.e.,* this moth cannot complete its life cycle without association of *Yucca* and *Yucca* has no other pollinator). The female moth visits the *Yucca* flowers at night, collects pollens under its head in the form of pollen ball, lays eggs in ovary of flower by inserting its ovipositor, climbs to the top of style and pushes the pollen ball into style lined with stigmatic tissue and thus bringing about pollination. The larvae of moth feed upon young seeds of *Yucca* and mature larvae grow into adults underground after escaping from ovary. The moth emerges from ground at the time of blooming of *Yucca.*

(iv) **Birds :** Pollination by birds is called **ornithophily,** *e.g.,* humming birds, honey eaters, sunbirds are sensitive to colours and have powerful vision. Main **ornithophilous** plants are *Strelitzia, Bignonia capreolata, Bombax, Callistemon, Erythrina,* etc.

- Ornithophilous flowers are characterized by tubular, cup-shaped or urn-shaped forms, bright colour, excess of nectar and pollens and generally odourless.
- *Strelitzia reginae* is pollinated by sunbirds.

(v) **Bats :** Pollination by bats is called **cheiropteriphily,** *e.g.,* in *Adansonia, Anthocephalus cadamba, Bauhinia, Kigelia africana* (sausage tree), *Mucuna gigantea,* etc.

- Cheiropterophilous plants bear single or cluster of flowers away from branches and foliage (due to long stalks), which helps in easy visit of bats to the flowers.

(vi) **Snails or Slugs :** Pollination by snails and slugs is called **malacophily,** *e.g.,* in **aroids** (members of fam. Araceae) like *Arisaema* (Snake plant).

(vii) **Ants or Termites :** Pollination by ants is called **myrmecophily** and such plants pollinated by ants are called **myrmecophytes,** *e.g.,* some members of family **Rubiaceae.**

COEVOLUTION OF FLOWERS AND POLLINATORS

The flowers pollinated by wind are generally inconspicuous and unscented. On the other hand most of the beautiful flowers of the world are pollinated by animals.

- The characteristic shapes, colours and odours of animal-pollinated flowers as well as life styles and sensory capabilities of their pollinators are an example of **coevolution.**

Coevolution may be defined as, "evolution in two species that interact extensively with one another so that each acts as a major force of natural selection on the other". When two species or two populations of a single species interact extensively, each exerts strong selective pressures on the other. When one evolves a new feature or modifies an old one, the other generally evolves new adaptations in response. This constant, mutual feedback between two species is called coevolution. This term coevolution was first introduced by **Erlich and Raven** (1964).

Predators and prey also provide an example of coevolution, which is a kind of 'biological arms race' with each side evolving new adaptations in response to escalations by the other.

- Animal-pollinated flowers must attract useful pollinators and frustrate undesirable visitors eating nectar or pollen without fertilizing the flower in return. The animals, inturn, have been under selective pressures to locate flowers quickly and identify the flowers that can provide them with sufficient nutrition in terms of nectar or pollen with minimum expenditure of energy.
- Flowers pollinated by animals can be grouped into three categories depending upon benefits which they provide to their potential pollinators :

(a) Food providing flowers
(b) Sex providing flowers
(c) Nursery providing flowers

Many flowers provide food for their animal pollinators like bees, beetles, moths, butterflies or humming-birds, etc., and animals, inturn, distribute pollens from flower to flower.

- o Coevolution of flowers and insect pollinators has produced diverse adaptations. Bees are responsible for most of the sweet-smelling flowers, because sweet flowery odours attract these pollinators. Bees also have good colour vision but they do not see same range of colours that humans do. Their colour vision extends into ultraviolet light range, which we can not see. Typically bee-pollinated flowers are white, yellow or blue and often have other markings such as central spots or lines pointing towards the centre that reflect UV-light. Similarly, bee-pollinated flowers have several structural adaptations that help to ensure pollen transfer, *e.g.*, these produce nectar at the bottom of the tube, pollen laden stamens or sticky stigma sticks out of the top of the tube and often a lower lip on the tube serves as a landing platform for bees. Moth and butterfly-pollinated flowers are superficially similar to bee-pollinated flowers but their nectar tubes are deep and narrow, which accommodate long tongues of moths and butterflies. Flowers pollinated by moths are usually white and with musky odours that help the moths in locating flowers in dark. Hummingbird-pollinated flowers have deep nectar-filled tubes as they need lot of energy.
- o In some flowers, **sexy deceptions attract pollinators,** *e.g.*, some orchid flowers mimic female wasps both in scent and shape. The males land on top of these flowers (females) and try to copulate but get only a packet of pollens. These are transferred to other flowers in next attempt.
- o Most elaborate relationships between plants and pollinators occur in a few cases in which insects fertilize a flower and then lay eggs in the flower's ovary. This relationship is found between milkweeds and milkweed bugs, figs and certain wasps and between *Yucca* and *Yucca* moths.

Hence we see that flowers show specific adaptations to pollination by particular pollinators, because of extensive coevolution between flowering plants and their pollinators.

FERTILIZATION

Process of fusion of male gamete with female gamete (egg) is called fertilization.

- Result of fertilization is zygote ($2n$), which undergoes predetermined mode of divisions to form **embryo.**
- Fertilization phenomenon was first reported by **Strasburger** (1884) in *Monotropa.*

Different steps in fertilization are:

(i) Germination of pollen on stigma

Pollen absorbs secretion of stigma (sugar, gum, resins and other liquid) and swells up. Exine ruptures and **intine** comes out in the form of **pollen tube.**

- Generally number of pollen tube from a single pollen is one, *i.e.*, **monosiphonous** condition, but in certain cases, many pollen tubes arise from a single pollen, *i.e.*, **polysiphonous condition,** *e.g.*, in families **Malvaceae,** (In *Malva,* upto 14 P. tubes) **Cucurbitaceae** and **Companulaceae**, etc. (but only one of them is functional).
- In **amentiferae** group (with naked flowers in catkin inflorescence), **branched pollen tube** is formed.
- Secretion of stigma is sticky and also prevents pollen as well as stigma from desiccation.

(ii) Path taken up by pollen tube

The pollen tube pierces through stigmatic papilla into tissue of style.

- Styles may be of any of the 3 types– **Open, half closed** and **closed.**
- When pollen tube reaches in ovary region, it enters into the ovule in either of the 3 ways :

(a) Through micropyle : This process of entry of pollen tube into ovule through micropyle is called **porogamy** and this is **most common** in angiosperms.

(b) Through chalaza : The process of entry of pollen tube into ovule through chalaza is called **chalazogamy,** *e.g.*, in *Betula, Casuarina* and *Juglans.*

(c) Through integuments or funiculus : The process is called **mesogamy,** *e.g.*, in *Cucurbita* (through integuments) and *Pistacia* (through funiculus).

- In porogamy, some workers are of opinion that **filiform apparatus** of synergids secrete some **chemotropically active substances,** which direct the pollen tube towards micropyle of ovule.

- Also a special ovular structure called **obturator** acts a bridge for growth of pollen tube towards micropyle.
- Ca^{2+} ions are naturally occurring **chemotropic agent** in the gynoecium or pistil and calcium controlled unidirectional growth of pollen tubes in the pistil is of universal occurrence.

(iii) Entry of pollen tube into embryo sac or female gametophyte

Whatever may be the mode of entry of pollen tube into the ovule, the pollen tube always **enters into the embryo sac at micropylar end.** This entry may be between egg and one synergid or between wall of embryo sac and synergid or through one synergid. So one synergid always is degenerated by pollen tube.

- On reaching of pollen tube inside the embryo sac, the 2 male gametes are discharged through a **sub-terminal** pore in pollen tube.
- The contents of pollen tube are discharged in the synergid and the pollen tube does not grow beyond it in the embryo sac. Further the cytoplasm of pollen tube is restricted to chalazal end of this synergidal cell.

(iv) Fusion of gametes

Inside the embryo sac, one male gamete fuses with egg cell to form zygote ($2n$) and this is called **syngamy or true act of fertilization.** The result of syngamy, *i.e.*, zygote ($2n$) ultimately develops into **embryo.**

The second male gamete fuses with 2 polar nuclei or secondary nucleus to form **triploid primary endosperm nucleus** and this is called **triple fusion.** The result of triple fusion, *i.e.*, primary endosperm nucleus ($3n$) ultimately develops into a nutritive tissue for developing embryo called **endosperm.**

- Thus syngamy and triple fusion occurs simultaneously in angiosperms and this is called **double fertilization,** reported first by S.G. Nawaschin (1898) in *Fritillaria* and *Lilium.*
- Double fertilization is **unique** and **universal** feature of **angiosperms.**
- (Total number of nuclei involved in double fertilization is five, *i.e.*, 2 in syngamy + 3 in triple fusion).
- Gerassimova (1930) reported that triple fusion occurs more quickly than syngamy.

Some abnormal features

(i) Polyspermy : Sometimes more than 2 male gametes or sperms may reach inside a single embryo sac, which is called polyspermy.

- This may be due to entry of more than one pollen tube inside embryo sac or due to presence of more than 2 male gametes in a single pollen tube.

In this condition, egg may be fertilized by more than one male gamete to form **polyploid zygote** or the extra male gametes fuse with synergids or antipodals, etc., to give rise to **polyembryony.**

(ii) Heterofertilization : When egg is fertilized with male gamete of one pollen tube and polar nuclei are fertilized with male gamete of other pollen tube, this phenomenon is called heterofertilization.

ENDOSPERM

Endosperm is a **characteristic storage tissue,** which supplies nutrition to the developing embryo. Development of endosperm is from primary endosperm nucleus (*i.e.*, result of triple fusion).

- The endosperm in gymnosperms is pre-fertilization tissue and is equivalent to female gametophyte, hence haploid in nature, but in angiosperms, it is **post-fertilization tissue** and is generally **triploid** in nature (however, ploidy level varies in different plants).
- No endosperm is formed in members of families **Orchidaceae, Podostemaceae** and **Trapaceae.**
- The endosperm may be totally utilized by developing embryo or some amount may be left in mature seeds.

Types of endosperm

On the basis of mode of development, there are 3 types of endosperm reported in angiosperms :

(i) Nuclear type
(ii) Cellular type
(iii) Helobial type

- These three types can be distinguished only after first division of primary endosperm nucleus.

(i) Nuclear type : This is the **most common type** of endosperm found in angiosperms and is reported in **161** families out of 288 for which record is available.

- Here **first and further divisions of primary endosperm nucleus** are not followed by cytokinesis or wall formation and thus these **free nuclear divisions** lead to formation of a large number of free nuclei in embryo sac. At maturity, **centripetal wall formation** (from periphery towards centre) may occur to make the tissue **partly cellular.**
- The nuclear type of endosperm is found in **Malvaceae, Juglandaceae, Papilionaceae,** etc.
- Endosperm haustoria are also developed in some cases and **largest endosperm haustoria** are found in *Echinocystis lobata* (16 mm in length) of family **Cucurbitaceae.**
- Endosperm of coconut is unique in sense that it is both **nuclear and cellular.**

(ii) Cellular type : It is reported in about **72 families** of angiosperms (mostly dicots).

- Here first and further divisions of primary endosperm nucleus are accompanied by cytokinesis or wall formation and thus the endosperm tissue is **completely cellular,** *e.g.*, in fam. **Magnoliaceae** (*Magnolia*) and **Acanthaceae** (*Barleria*).

In *Loranthus* and *Santalum*, the ovules are ategmic (without integuments) and different embryo sacs lie freely in ovary. Then endosperms of different embryo sacs unite together to form a unique type of endosperm called **composite endosperm.**

(iii) Helobial type : This is intermediate between first two. It is found in mostly monocots (about 17 families).

- Here first division of primary endosperm nucleus is followed by wall formation to form **two chambers** (like cellular type), but further nuclear divisions in both chambers are free nuclear divisions (just like nuclear type). The endosperm mostly develops **from micropylar chamber**, *e.g.*, in families of order **Helobiales** like **Alismaceae, Butomaceae, Hydrocharitaceae, Najadaceae,** etc.

Some special types

(i) Ruminate endosperm : When **surface of endosperm is uneven or having ridges and furrows,** it is called ruminate endosperm.

- This type of endosperm is reported in about 32 families of angiosperms like **Rubiaceae, Annonaceae, Aristolochiaceae, Palmaceae, Myristicaceae,** etc.
- Ruminate endosperm is formed due to uneven, hard seed coat outer to soft endosperm.

(ii) Mosaic endosperm : In some cases, the tissue of endosperm is **not homogeneous** but there are patches of different colours, *i.e.*, heterogeneous. Such type of endosperm is called mosaic endosperm.

- Common example of mosaic endosperm is in *Zea mays* (maize), where there are distinct yellow and white patches.

Cytology of endosperm

Endosperm tissue is generally **triploid** ($3n$), but different levels of ploidy are found in endosperm of different plants (depending upon no. of polar nuclei in embryo sac), *e.g.*,

- In *Pepromea*— **$9n$** (8 polar nuclei + 1 male gamete)
- In *Penea, Plumbigella, Fritillaria, Plumbago*—**$5n$**
- In *Oenothera*— **$2n$**
- As **endomitosis** is common in endosperm, hence high level of polyploidy is found here. Highest level of ploidy is in *Arum maculatum*, *i.e.*, **24576 n.**

Histology of endosperm

Being storage tissue, the cells of endosperm are **isodiametric, thin-walled** and generally **without pits.**

- In cereals, one of few outer layers of endosperm are thick-walled with dense cytoplasm having pits. These are mainly filled with **aleurone grains** (highly protein rich) and hence called **aleurone tissue** or **aleurone cells.**
- Aleurone layer/layers secrete some **hydrolytic enzymes** like **amylases** and **proteases,** which break down starch and protein into simple substances, utilized during seed germination (Gibberellins released by embryo stimulate amylase and protease enzyme secretion at aleurone layer).
- Cells of endosperm are generally non-green or non-chlorophyllous, but in *Crinum, Viscum, Raphanus* and *Mathiola,* etc., **chlorophyllous endosperm** is present (when exposed to light).

Function of endosperm

It is **storage tissue** having carbohydrates, proteins, fats, etc., and is having **nutritive function.**

(a) Endosperm provides nutrition to developing embryo. It not only nourishes its own embryo, but also provides nutrition to embryos of other plants (especially young endosperm), *e.g.*,

- **Coconut milk** (Liquid endosperm of coconut)— Contains **auxins, cytokinins** and **GA** and **induces cytokinesis.**
- **Young endosperm of maize** (milky) also induces cytokinesis and a very common **cytokinin 'zeatin'** is extracted from milky endosperm of maize.
- Mature endosperm is **not having stimulatory property.**

(b) During seed germination, the endosperm substances are digested and are utilized in seedling growth.

Morphological nature of endosperm

This is controversial subject and the most accepted view is of **Nemec, Brink and Cooper** (1942), *i.e.*, it is neither gametophytic nor sporophytic tissue, but it is undifferentiated tissue with different ploidy levels.

Endospermic and non-endospermic seeds

At maturity of seeds, endosperm may be fully utilized by embryo or some amount may be left unutilized. On this basis, there are two types of seeds:

(i) Non-endospermic seeds or ex-albuminous seeds : Here **no endosperm is left at maturity** in seeds or seeds are without endosperm. Cotyledons of seeds are thick here due to storage of food, *e.g.*, seeds of gram, pea, beans, tamarindus (Imli), orchids, etc., are **non-endospermic or exalbuminous seeds.**

(ii) Endospermic or Albuminous seeds : Here endosperm is not fully utilized and some amount is left in seeds. Cotyledons are thin here.

e.g., seeds of wheat, rice, barley, castor, poppy, palms, etc., are **endospermic or albuminous.**

Some other specific terms related to endosperm

(i) Xenia : This term was first given by **Focke** (1881) for the direct effect of pollens on structures inside embryo sac except embryo. But now the term **xenia** is used in strict sense to denote **direct effect of pollens on endosperm character.**

e.g., when **yellow endosperm race** of maize (used as ♂) is crossed with **white endosperm race,** yellow endosperm is obtained in same generation, so maize is example of xenia.

(ii) **Metaxenia :** This term was first used by Swingle (1928) for denoting effect of pollens on structures outside embryo sac or endosperm (seed coat/fruit wall), *i.e.*, in date palm maturity time as well as size of fruits can be changed by using different pollens, hence date palm is example of metaxenia.

EMBRYO

Fertilized egg is known as **zygote** (2*n*), which gives rise to **embryo** after predetermined mode of divisions. This process of development of embryo is called **embryogenesis.**

- Before development, zygote undergoes a resting period which is shorter in cellular endosperm and longer in nuclear endosperm.
- An embryo has the capacity to develop into a complete plant (Thus embryo is future miny or tiny plant inside the seed).
- The development and structure of dicot and monocot embryos are different from each other.

Dicot embryo

A typical dicot embryo (common type is **onagrad type** or ranunculaceous type) is having an **embryonal axis** and **2 cotyledons** attached to it laterally.

The portion of **embryonal axis above** the point of attachment of cotyledons is called **epicotyl** and the portion below the point of attachment of cotyledons is called **hypocotyl.**

- At the terminal end of epicotyl is **plumule** (embryonic shoot) and the hypocotyl at its end bears **radicle** (embryonic root).

Monocot embryo

Monocot embryo differs from a dicot embryo mainly in having a **single cotyledon** (instead of two).

- In grasses (monocots), structure and development of embryo is **different from other monocots.**
- o A **grass embryo** (*e.g., Triticum* or wheat) is having single cotyledon, which is called **'scutellum'** (or single cotyledon of grass embryo is called **scutellum**). The embryonal axis below the attachment of scutellum is called **hypocotyl,** which at its tip is having **radicle,** bearing **apical meristem** and **root cap** at its lower end. The radicle and root cap is covered by an envelope or covering called **coleorhiza.**
- Embryonal axis above the level of scutellum is called **epicotyl,** which terminates into **plumule with shoot apex,** which is also enclosed in a hollow structure or covering called **coleoptile.**

(Covering of radicle is **coleorhiza** and covering of plumule is called **coleoptile**).

- Reduced or underdeveloped embryos are found in certain families like **Balanophoraceae, Burmanniaceae, Orchidaceae, Orobanchaceae, Rafflessiaceae, Gentianaceae,** etc., (mostly saprophytes and parasites).

Nutrition of embryo

Main nutritive tissues for embryo are:

(i) **Endosperm :** (*already explained)

(ii) **Perisperm** (remnant of nucellus): (*already explained)

(iii) **Chalazosperm :** Nucellar cells in chalazal region of ovule is called **chalazosperm,** which stores fats and starch and is substitute for endosperm.

- Chalazosperm is found in *Cyanastrum.*

FORMATION OF SEED AND FRUIT

Seed

- **Ovules at maturity or ripened ovules are known as seeds.**
- Integuments of ovule form **seed coat. Outer integument forms testa and tegmen** (in castor bean, etc.) develops from **inner integument.**
- In some cases like **Litchi, Ingadulce** (*Pithecolobium*), *Asphodelus, Trianthema, Ulmus,* etc., a sort of third **integument** or **aril** is present, which forms an additional covering of seed.
- Some seeds like **castor** (*Ricinus communis*) have a spongy outgrowth near the micropyle, which is known as **caruncle** and it absorbs water during seed germination.
- Funiculus (stalk of ovule) forms stalk of the seed. Ultimately, stalk withers and leaves a minute scar called **hilum.**
- Antipodals, synergids disorganize and nucellus may disappear or persist as **perisperm.**
- **Smallest or minuest seeds are found in orchids,** which are lightest in plant kingdom and are called **dust seeds.** Fresh wt. of each orchid seed is **20.33 µg.**
- **Largest seeds are of 'double coconut' or 'cocodemur'** (*Lodoicea maldivica*), which are **bilobed** and each seed is having **weight of 6 Kg.**

Fruit

- **Ripened ovary or fertilized ovary is called fruit.**
- **Wall of the ovary forms fleshy or dry fruit wall (pericarp).** Fleshy fruit wall or pericarp is having 3 **layers-epicarp, mesocarp and endocarp.**
- In drupe fruits (like mango and coconut), **epicarp is thin, leathry; mesocarp is pulpy** (*e.g.*, mango) or **fibrous** (coconut) **and endocarp is hard, stony.**
- In most of the cases, sepals, petals and thalamus do not constitute part of fruit, but in apple, peach, etc., thalamus becomes fleshy and forms edible portion of fruit.

- **Lightest or smallest fruits** are found in some grasses, whereas **largest fruits are in double coconut** or **cocodemur** (Lodoicea maldivica). Each fruit of cocodemur is 1 metre in length and 18 Kg in weight.

LIFE HISTORY OF ANGIOSPERMS OR ALTERNATION OF GENERATIONS IN ANGIOSPERMS

In a typical angiospermic plant, there are two phases or generations in its life cycle. First is complex, independent generation called **sporophyte** (2n), which is differentiated into root, stem and leaves, whereas second is simple or reduced, inconspicuous and dependent or parasitic upon sporophyte, called **gametophyte** (n). These two phases or generations follow each other in a definite sequence or these alternate with each other, which is called **alternation of generations** (term was first used by **Hofmeister**, 1851). (Fig. 17.7)

- **Sporophytic phase** begins with fertilization and ends with meiosis, whereas **gametophytic phase** starts with reduction division or meiosis and ends with fertilization. Thus **fertilization and meiosis** are two **regular features** of life cycle of angiosperms.

Certain problems regarding chromosome number and meiotic division, etc., related to life cycle of angiosperms.

Question 1. *Number of chromosomes in root cells (or leaf cells or stem cells or somatic cells) is 24, what will be the number of chromosomes in–*

(a) Nucellus
(b) Integuments
(c) Megaspore mother cell
(d) Endosperm
(e) Synergids
(f) Antipodals
(g) Secondary nucleus
(h) Pollens
(i) Megaspore ?

Solution : No. of chromosomes in root cells is 24.

i.e., $2n = 24$ (sporophytic)

So number of chromosomes in different tissues are:

(a) Nucellus $= 2n = 24$
(b) Integuments $= 2n = 24$
(c) Megaspore mother cell $= 2n = 24$
(d) Endosperm (result of triple fusion) $= 3n = 36$
(e) Synergids (part of gametophyte) $= n = 12$
(f) Antipodals (part of gametophyte) $= n = 12$
(g) Secondary nucleus (formed by fusion of 2 polar nuclei) $= 2n = 24$
(h) Pollens (formed after meiosis) $= n = 12$
(i) Megaspore (formed after meiosis) $= n = 12$

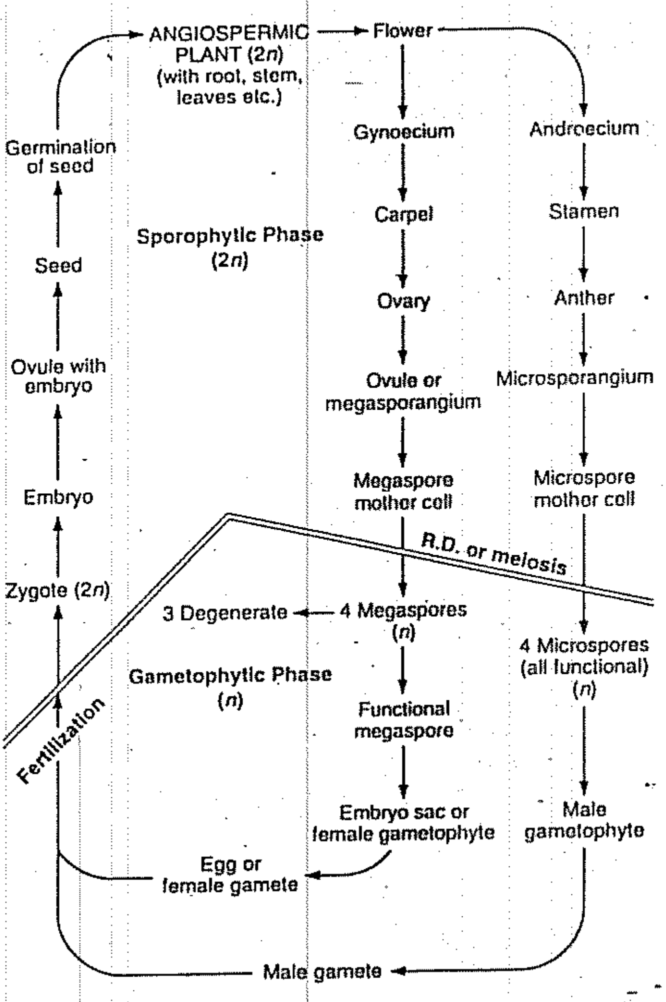
ANGIOSPERMIC PLANT (2n) (with root, stem, leaves etc.)
Flower
Gynoecium
Androecium
Carpel
Stamen
Ovary
Anther
Ovule or megasporangium
Microsporangium
Megaspore mother cell
Microspore mother cell
R.D. or meiosis
4 Megaspores (n)
3 Degenerate
4 Microspores (all functional) (n)
Functional megaspore
Embryo sac or female gametophyte
Male gametophyte
Egg or female gamete
Male gamete
Fertilization
Zygote (2n)
Embryo
Ovule with embryo
Seed
Germination of seed
Sporophytic Phase (2n)
Gametophytic Phase (n)

Fig. 17.7. Schematic representation of alternation of generations in a typical angiospermic plant

Question 2. *If haploid number of chromosomes is 6, then what will be the number of chromosomes in–*

(a) Nucellus
(b) Integuments
(c) Endosperm
(d) Synergids
(e) Antipodals ?

Solution : Here $n = 6$

So number of chromosomes in different tissues are:

(a) Nucellus $= 2n = 12$
(b) Integuments $= 2n = 12$
(c) Endosperm $= 3n = 18$
(d) Synergids $= n = 6$
(e) Antipodals $= n = 6$

Question 3. *If number of chromosomes in endosperm is 30, what will be the number of chromosomes in nucellus?*

Solution : No. of chromosomes in endosperm, *i.e.*,

$$3n = 30$$

Hence, no. of chromosomes in nucellus = $2n = 20$

(as $n = 10$)

Question 4. *How many meiotic divisions are necessary for formation of 100 pollen grains?*

Solution : As 4 pollen grains are produced by R.D. or meiotic division of one pollen mother cell, so meiotic divisions in 25 PMC are necessary to form 100 pollen grains.

Hence, number of meiotic divisions necessary for formation of 100 pollens = 25.

Question 5. *How many meiotic divisions are necessary for formation for 100 megaspores?*

Solution : No. of meiotic divisions necessary for formation of 100 megaspores = 100 (*as by meiotic division of a megaspore mother cell, 4 megaspores are produced, out of which 3 degenerate and only 1 survives).

Question 6. *If development is normal and there is complete success of pollination and fertilization, then how many meiotic divisions are necessary for 100 zygote formation?*

Solution : For formation of 100 zygotes, 100 male gametes and 100 female gamets (eggs) are required. 100 male gametes are developed from 100 microspores (from 25 meiotic divisions) and 100 eggs are developed from 100 megaspores (from 100 meiotic division).

Hence, number of meiotic divisions necessary for 100 zygotes formation = 25 + 100 = 125.

Question 7. *How many meiotic divisions are necessary for 100 grains formation in wheat?*

Solution : 125 (Similarly, as in above question).

Question 8. *How many meiotic divisions are necessary for 100 seeds formation in family Cypraceae?*

Solution : There is an exception in Cypraceae in **microsporogenesis**, *i.e.*, out of 4 microspores formed after R.D. of a microspore mother cell, 3 degenerate and only 1 survives (as in formation of megaspores).

Hence, number of meiotic divisions necessary for formation of 100 seeds in Cypraceae = 100 + 100 = 200.

POLYEMBRYONY

- Presence of more than one embryo inside the seed is called **polyembryony.**
- Besides normal zygotic embryo, other embryos formed inside the seed may be **diploid** or **haploid.**
- Polyembryony phenomenon is **more common in gymnosperms** than angiosperms. **In angiosperms,** it is generally present as **unusual feature** except few cases like *Citrus*, mango, etc.
- Polyembryony was first reported by **Anton van Leeuwenhoek** (1719) in *Citrus*.

Earlier workers divided polyembryony into two types:

1. True polyembryony

When inside a single embryo sac, many embryos are present.

2. False polyembryony

When more than one embryo sacs are present in an ovule and many embryos are present in different embryo sacs.

In angiosperms, polyembryony may be due to:

(a) Cleavage of proembryo

Here zygote or proembryo divides into many portions or units and then each portion develops into an embryo. This is the simplest method of polyembryony, *e.g.*, in family Orchidaceae.

(b) Development of many embryos from other cells of embryo sac except egg

e.g., from synergids in *Argemone, Phaseolus vulgaris, Aristolochia bracteata, Sagittaria, Poa alpina*, etc., these embryos may be **haploid** or **diploid** depending upon whether the synergids are fertilized or not.

- **From antipodals** —In *Paspalum, Ulmus.*
- **From endosperm** —Rare as in *Balanophora.*

(c) Formation of many embryos due to presence of more than one embryo sac in the same ovule

e.g., In *Citrus, Casuarina, Poa pratensis.*

(d) Many embryos from the structures outside the embryo sac (like nucellus and integuments)

This is commonly called **adventive polyembryony,** *e.g.*, **from nucellus** (very common)— in *Citrus* (upto 10 nucellar embryos), mango, opuntia, etc.

From integuments : In *Spiranthes australis.*

- ○ A special and interesting case of polyembryony is found in *Allium odorum*, where 5 embryos develop by **different methods,** *e.g.*,

  1 → Zygotic, 1 → synergidal, 2 → from antipodals and 1 → from integuments.

- ○ Maximum number of embryos, *i.e.*, 40 are reported inside single seed of *Citrus unshiu.*

Cause of polyembryony

Most important theory of cause of polyembryony is **necroharmone theory given by Haberlandt (1921),** *i.e.*, a stimulus for polyembryony is provided by **degenerating cells of nucellus.**

Practical importance of polyembryony

In horticultural plants (*e.g.*, *Citrus*, mango, etc.), **genetically uniform parental type seedlings** are obtained **from nucellar embryos. These** are superior to those obtained by cutting (*i.e.*, vegetative propagation) because nucellar embryos seedling are **disease free** and **maintain their superiority for a long duration.**

APOMIXIS

Normal type of sexual reproduction having **two regular features**, *i.e.*, meiosis and fertilization, is called **amphimixis.** But in some plants, this normal sexual reproduction (amphimixis) is replaced by some abnormal type of sexual reproduction called **apomixis.**

- The term **apomixis** was first given by **Winkler** (1908).
- Apomixis may be defined as, 'abnormal kind of sexual reproduction in which egg or other cells associated with egg (synergids, antipodals, etc.) develop into embryo without fertilization and with or without meiosis'.

Or

In strict sense :

'Apomixis is unusual sexual reproduction where there is no meiosis and syngamy'.

Apomixis is mainly of 2 types:

1. Vegetative reproduction

In which plants develop from parts other than seed, *e.g.*, from bulbils, suckers, runners, stolons, etc.

2. Agamospermy

Here the plants **produce seeds as means of propagation (*seminiferous plants)**, but embryo inside the seed is produced by **abnormal method omitting meiosis and fertilization.** It is of following types :

(i) Adventive embryony : Development of embryos directly from sporophytic tissues like **nucellus** and **integuments is adventive embryony,** *e.g.*, in *Citrus*, mango, etc.

(ii) Diplospory : Here archesporium develops inside the nucellus of ovule, which gives rise to **megaspore mother** cell, which directly without R.D. develops into **diploid embryo sac** (having diploid egg, synergids, antipodals, etc.). This phenomenon is called **diplospory** (also called generative apospory).

Now the diploid egg may develop into embryo without fertilization, called **diploid parthenogenesis,** *e.g., Taraxacum.*

Or.

Embryo may be developed from other diploid cell of embryo sac (other than egg) without fertilization, which is called **diploid apogamy,** *e.g.*, in *Antennaria, Alchemilla*, etc.

(iii) Apospory (or somatic apospory) : Development of embryo sac directly from a cell of nucellus ($2n$) is called **apospory.** The diploid egg develops into embryo parthenogenetically.

e.g., in *Ranunculus, Rubus, Parthenium*, etc.

- According to famous Indian embryologist **P. Maheshwari,** there are 2 types of apomixis:

1. Recurrent apomixis

In which **vegetative propagation and agamospermy** are included.

2. Non-recurrent apomixis

Here in ovule

$$\begin{tikzcd}
\text{Megaspore mother cell } (2n) \arrow[r, "\text{R.D.}"] & \text{Megaspore } (n) \arrow[r] & \text{Embryo sac } (n) \arrow[d] \arrow[dd, bend left] \\
\text{(Haploid parthenogenesis) Embryo } (n) & & \text{Haploid egg} \arrow[ll, "\text{Without}", "\text{fertilization}"'] \\
\text{(Haploid apogamy) Embryo } (n) & & \text{Haploid other cells} \arrow[ll, "\text{Without}", "\text{fertilization}"']
\end{tikzcd}$$

- ○ (**Parthenogenesis**— Development of embryo from egg without fertilization).
- ○ (**Apogamy**— Development of embryo from cells other than egg inside embryo sac (synergids, antipodals) without fertilization).

PARTHENOCARPY

- The term **parthenocarpy** was given by **Noll** (1902).
- Development of fruits without fertilization is called **parthenocarpy** and such fruits are called **parthenocarpic fruits.**
- Parthenocarpic fruits are seedless.
- Important examples of **parthenocarpic fruits** are: Banana, papaya, guava, pineapple, apple, grapes, *Cucurbita*, etc.
- Parthenocarpy can also be induced artificially by:

(a) Spraying auxins and gibberellins

(b) Delayed pollination

(c) Use of foreign pollen grains

(d) Use of powdered **pollens and pollen extracts.**

(e) Cutting style from base and applying chemicals like IAA, IBA, NAA, etc., in **lanolin paste at cut surface.**

- ○ (For parthenocarpy induction by auxins, these should be applied **after anthesis** (first opening of flower) and by gibberellins, these should be applied earlier, *i.e.*, at anthesis).

EXPERIMENTAL EMBRYOLOGY OR APPLIED EMBRYOLOGY

Tissue Culture

Tissue culture technique is the **latest and most promising method** of plant improvement, (specially in those cases when conventional methods of breeding fail).

- Tissue culture is based on **totipotent** nature of plant cells or **concept of totipotency,** *i.e.*, each and every plant cell has inherent capacity to develop into a complete plant.
- Concept of totipotency was given by **Haberlandt** (1902) and practical aspect of it was shown by **Steward** (1932), when he developed a full plant from a single cell of **wild-carrot root.**

- Tissue culture techniques have reduced the time as compared to conventional methods.
- Any cell or group of cells used for tissue culture is called **'explant'**.

$$\text{Explant} \xrightarrow{\text{Culture med.}} \underset{\text{i.e., callus}}{\underset{\text{mass of cells,}}{\text{Undifferentiated}}} \xrightarrow{\text{Differentiation}} \underset{\text{plantlet}}{\underset{\text{or}}{\text{Seedling}}}$$

Nutrient medium

Different cells or organs have different nutritional requirement.

- Most of the media contain **inorganic salts of macro and micro elements + vitamins + sucrose** (as C–source), called **basal medium. This basal medium** also require some growth regulators (auxins, GA, cytokinins, etc.), natural plant extracts (coconut milk, fruit juices), casein hydrolysate, yeast extract, etc. Now this medium is called **supplimented medium.**

Different types of tissue culture techniques are:

1. Haploid production by pollen culture

Haploids have a single set of chromosome, so are of great significance especially in studies on induction of mutation (even a small change can be detected in them) and also for **production of homozygous diploids** by colchicine treatment.

- Best method of haploid production is **pollen culture.**
- Process of haploid production from pollen is called **androgenesis,** which was first noticed by **Tuckele** (1958) in *Ginkgo biloba.*
- **Guha and Maheshwari** (1964) reported direct development of embryoids from pollens of *Datura innoxia* by culture of excised anther.

(Embryoids—Embryo like structures or non-zygotic/somatic embryos which are produced through tissue culture (*i.e., in vitro*). Every plant cell develops like normal zygote into **embryoid,** if provided with suitable conditions).

- Some diploid plants are produced along with haploid plants **from cells of antherwall.**
- **Distant hybridization** is another method of **haploid production.**

2. Embryo culture

Embryo culture technique was started by **E. Hannig** (1904) in **crucifers** which was improved by **Laibach** (1925).

- Embryo culture is used in:

(a) Shortening of breeding cycle.
(b) To obtain rare hybrids.
(c) To propagate some rare plants.
(d) Used as rapid seed viability test.

3. Endosperm culture

- Endosperm culture is used for **triploid plant production.**
- **Triploids** are usually seed sterile or triploids are associated with seedlessness, so these may be exploited for seedless nature of fruits.
- As triploids are usually seed sterile so **undesirable for plants where seeds are commercial product.**
- Triploidy is in commercial use in many varieties of apple, banana, mulberry, sugarbeet, tea, watermelon, etc.

4. Protoplast culture

This is recent development in the field of tissue culture.

- Most **important use of protoplast culture is somatic hybridization or production of somatic hybrids.**
- First case of **somatic hybrid** in plants was reported by **Carlson** (1972) in *Nicotiana langsdorffii* × *N. glauca.*

Difficulty in somatic hybridization is that at the time of crossing, the two **protoplast nuclei** may be in **different cell cycles,** so there is failure of fusion of nuclei and only **cytoplasm** fuse, hence true hybrid is not obtained but **cytoplasmic hybrid** or **'cybrid'** is obtained.

Genetic engineering through protoplast culture– Due to **fragile nature** of protoplast membrane, small or large molecules like DNA, virus, bacteria or even whole nuclei or chloroplast can be introduced, so **desirable characters** can be incorporated in plants, *e.g.,* **nitrogen fixation genes (nif** genes) can be introduced into non-legumes by protoplast culture.

(Chloroplast + 'nif' genes ⟶ Nitroplast).

5. Nucellus culture

Genetically uniform and disease free clones have been produced by nucellus culture, *e.g.,* in *Citrus,* mango, etc.

6. Meristem tip culture

Used in : (a) Clonal propagation;
(b) In obtaining virus free plants.

- Obtaining plants by tissue or cell culture is called **micropropagation.**

7. Cryobiology

Dry-freezed storage of germplasm is called cryobiology.

Fruits

MULTIPLE CHOICE QUESTIONS

*1. Which is not possessed by a staminate flower?
(a) Stalk (b) Bract
(c) Bracteole (d) Pistil

2. Egg apparatus is made of:
(a) Only egg (b) Egg and antipodals
(c) Eggs and polar nuclei (d) Egg and synergids

3. Egg apparatus is situated at:
(a) Micropylar end
(b) Chalazal end
(c) At periphery
(d) In the centre of embryo sac

4. The inner most layer of pollen chamber which acts as nutritive layer is called: **(BHU 2001; Raj. PMT 2002)**
(a) Tapetum (b) Endothelium
(c) Endothecium (d) Perisperm

5. Formation of embryo sac directly from megaspore mother cell in angiosperms is called :
(a) Apospory (b) Apogamy
(c) Diplospory (d) Agamospermy

6. Germ pores are found in:
(a) Ovules (b) Seeds
(c) Microspores (d) Megaspores

7. Accessory whorls of the flower are:
(a) Calyx and epicalyx
(b) Calyx and corolla
(c) Androecium and gynaecium
(d) Corolla and androecium

8. Embryo sac represents: **[BCECE (P.T. Exam.) 2001]**
(a) Megasporangium (b) Megaspore
(c) Female gametophyte (d) Female gamete

9. Meiosis occurs in angiosperms when:
(a) Flowers are formed
(b) Seeds are formed
(c) Pollen grains are formed
(d) None of the above

10. The most common type of ovule in angiosperms is:
(a) Orthotropous (b) Anatropous
(c) Hemianatropous (d) Circinotropous

11. In anatropous ovule, the micropyle is:
(a) In straight line with funicle
(b) At right angles with funicle
(c) At 45° with funicle
(d) Side by side with funicle

12. Caruncle is derived from:
(a) Peduncle (b) Cotyledon
(c) Integument (d) None of these

13. Carpels represent:
(a) Megasporophylls (b) Megasoporangia
(c) Microsporagia (d) Microsporophylls

14. Pollen tube at the time of entering the embryo sac has:
(a) 4-gamete nuclei (b) Single gamete nucleus
(c) 3-gamete nuclei (d) 2-gamete nuclei

*15. Upon fertilization, what structure develops from carpel?
(a) Testa (b) Tegmen
(c) Pericarp (d) Perisperm

16. Embryoids are:
(a) Immature embryos
(b) Non-zygotic embryos developed through tissue culture
(c) Embryos formed by parthenogenesis
(d) Embryos which lack vitality

17. Sexuality in plants was observed by:
(a) Grew (b) Kolreuter
(c) Camerarius (d) Amici

18. Term 'Alternation of generations' was first used in plants by:
(a) Amici (b) Hofmeister
(c) Kolreuter (d) None of these

19. Actual fusion of male gamete with egg (syngamy) was observed in *Monotropa* by:
(a) Nawaschin (b) Strasburger
(c) Schleiden (d) Amici

20. Double fertilization was first reported by Nawaschin in :
(a) *Portulaca* (b) *Fritillaria*
(c) *Monotropa* (d) None of these

21. Foremost Indian embryologist was:
(a) S.C. Maheshwari (b) P. Maheshwari
(c) H.Y. Mohan Ram (d) None of these

22. Modified shoot with highly condensed internodes is:
(a) Leaf (b) Flower
(c) Microsporophyll (d) Megasporophyll

23. Anther is generally :
(a) Monosporangiate (b) Bisporangiate
(c) Tetrasporangiate (d) Trisporangiate

24. Single microsporangium per anther is found in:
(a) *Gossypium* (b) *Hibiscus*
(c) *Arceuthobium* (d) *Najas*

25. Main function of endothecium (in anther) is:
(a) Mechanical (b) Nutritive
(c) Dehiscence (d) None of these

26. Simultaneous type of cytokinesis in microspore mother cells leads to:
(a) Isobilateral tetrad (b) Tetrahedral tetrad
(c) Linear tetrad (d) None of these

27. Isobilateral pollen tetrad is common in:
(a) Monocots (b) Dicots
(c) Both (a) and b) (d) None of these

28. Filiform pollen grains are found in:
(a) *Aristolochia* (b) *Zostera*
(c) *Drimys* (d) *Juncus*

29. Compound pollen grains are found in:
(a) *Cypripedium* (b) *Calotropis*
(c) *Typha* (d) None of these

30. Compound pollens held together in small units are called:
(a) Pollinium (b) Massulae
(c) Translator (d) None of these

31. Translator apparatus is found in:
(a) Asclepiadaceae (b) Malvaceae
(c) Droseraceae (d) None of these

32. 'Callase' enzyme which dissolves callose of pollen tetrads to separate 4 pollens is provided by:
(a) Pollens (b) Tapetum
(c) Middle layers (d) Endothecium

33. Terms Intine and Exine were proposed by:
(a) Amici (b) Strasburger
(c) Fritsche (d) None of these

34. Number of germ pores in exine are :
(a) 1 (b) 2
(c) 1 or many (d) 4

35. Pollen grains are preserved for long periods in fossils due to:
(a) Cellulose (b) Sporopollenin
(c) Carotenoids (d) Ubisch bodies

36. Ubisch bodies are provided by: **(BHU 1999)**
(a) Tapetum (b) Pollen kitt
(c) Exine (d) Intine

37. Smallest pollens are in:
(a) *Cucurbita* (b) *Nyctanthes*
(c) *Myosotis* (d) *Hyacinthus*

38. 'Pollen grains embryo sacs' were first observed in:
(a) *Hymenocallis* (b) *Elodaea*
(c) *Hyacinthus* (d) None of these

39. Which forms maximum proportion in chemical composition of pollens?
(a) Proteins (b) Fats
(c) Carbohydrates (d) Water

40. 'Nemec phenomenon' relates to:
(a) 7 celled female gametophyte
(b) 8 nucleated male gametophyte
(c) Formation of pollen kitt
(d) None of the above

41. Study of pollen grains is called:
(a) Micrology (b) Microsporogenesis
(c) Palynology (d) Aerology

42. Poisonous pollens are in : **(CPMT 1995)**
(a) *Alnus* (b) *Citrus*
(c) *Putranjiva* (d) *Serjania*

43. Iatropalynology is:
(a) Medicinal aspects of pollen grains
(b) Fossil pollen grains
(c) Pollens in relation to honey
(d) None of the above

44. Important 'Aeroallergen' in India is:
(a) *Amaranthus spinosus* (b) *Serjania*
(c) *Borassus flabellifer* (d) *Holoptelea*

45. Pollens are shed from anther generally at:
(a) Single celled stage (b) 2-celled stage
(c) 3-celled stage (d) 4-celled stage

46. Which is the most common type of ovule?
(a) Unitegmic (b) Bitegmic
(c) Ategmic (d) None of these

47. Ategmic ovule is present in which plant?
(a) *Casuarina*, (b) *Opuntia*
(c) *Loranthus* (d) None of these

48. Micropyle in ovule is mostly formed by:
(a) Outer integument (b) Inner integument
(c) Both (a) and (b) (d) None of these

49. Embryo sac is present embedded in nucellus at which end of ovule?
(a) Micropylar end (b) Chalazal end
(c) In the centre (d) None of these

50. Multilayered endothelium (Integumentary tapetum) is present in which of the following families?
(a) Malvaceae (b) Compositae
(c) Cruciferae (d) None of these

51. Cells of endothelium are:
(a) Haploid (b) Diploid
(c) Polyploid (d) Triploid

52. Obturator in ovule is generally derived from:
(a) Placenta (b) Funiculus
(c) Integument (d) Nucellus

53. When megaspore mother cell (sporogenous cell) is hypodermal in position and nucellar tissue around it is single layered, this type of ovule is called:
(a) Crassinucellate (b) Tenuinucellate
(c) Amphitropous (d) Circinotropous

54. Group of lignified cells above the vascular supply of funiculus, which acts as barrier for the growing embryo sac into the base is called:
(a) Nucellar beak (b) Epistase
(c) Hypostase (d) Perisperm

55. Single functional megaspore which develops into embryo sac is:
(a) First at micropylar end
(b) Second from micropylar end
(c) First at chalazal end
(d) Second from chalazal end

56. In which family, a prominent air space is present between two integuments at chalazal end?
(a) Aristolochiaceae (b) Cactaceae
(c) Compositae (d) None of these

57. Stomata and chlorophyll are present in integuments of:
(a) *Cleome* (b) *Ulmus*
(c) *Hymenocallis* (d) *Asphodelus*

58. Collar like outgrowth from the base of ovule forming a sort of IIIrd integument is called:
(a) Caruncle (b) Aril
(c) Chalazosperm (d) None of these

59. Red coloured 'mace' which is used as condiment is obtained from nutmegs and is:
(a) Integument (b) Aril
(c) Caruncle (d) Perisperm

60. In which of the following series of plants, 'aril' is present?
(a) *Litchi, Ulmus,* Ingadulce, Nutmeg
(b) *Trianthema,* Nutmeg, *Ricinus, Asphodelus*
(c) *Ricinus, Cyanastrum,* Nutmeg, Dulce
(d) None of the above

61. The normal type of embryo sac development is:
(a) *Oenothera* type (b) *Polygonum* type
(c) *Allium* type (d) *Pepromea* type

62. Fully developed female gametophyte in angiosperms is:
(a) 8 nucleated, 8 celled (b) 8 nucleated, 6 celled
(c) 7 nucleated, 8 celled (d) 8 nucleated, 7 celled

63. In 'Adoxa type' of female gametophyte, the number of polar nuclei are:
(a) 2 (b) 4
(c) 8 (d) 1

*64. The constant feature of embryo sac is:
(a) Synergids (b) Antipodals
(c) Egg (d) Polar nuclei

65. Filiform apparatus is the feature of:
(CPMT 1999; AFMC 2002)
(a) Egg (b) Synergids
(c) Antipodal (d) None of these

66. Hundreds of antipodals are found in: **(CPMT 1993, 95)**
(a) *Bambusa* (b) *Sasa*
(c) *Gossypium* (d) None of these

67. How many meiotic divisions are required to produce 200 seeds in *Juncus*:
(a) 400 (b) 200
(c) 300 (d) 250

68. The 2 polar-nuclei of embryo sac are derived from:
(a) Both from micropylar end
(b) Both from chalazal end
(c) One each from micropylar and chalazal end
(d) None of the above

69. The flowers which expose their mature anthers and stigma to the pollinating agents are called:
(a) Cleistogamous (b) Autogamous
(c) Pseudogamous (d) Chasmogamous

70. In *Commellina,* cleistogamy is found in:
(a) Aerial flowers (b) Underground flowers
(c) Both (a) and (b) (d) None of these

71. Transfer of pollens from anther to stigma of different flower on other plant is called:
(a) Autogamy (b) Geitonogamy
(c) Xenogamy (d) None of these

72. 'Herkogamy' is found in:
(a) Cotton (b) Marigold
(c) Calotropis (d) Bajra

73. Anemophilous plants have:
(a) Enormous and small light pollens
(b) Small and inconspicuous flowers
(c) Reduction in number of ovules/ ovary
(d) All of the above

74. Nocturnal flowers are pollinated by:
(a) Bees (b) Wasps
(c) Flies (d) Moths

75. 'Turn pipe' mechanism of pollination occurs in:
(a) *Zostera* (b) *Calotropis*
(c) *Salvia* (d) *Orchids*

76. Main insect behind entomophily is:
(a) Moths (b) Wasps
(c) Bees (d) Beetles

77. Pollination by act of 'Pseudocopulation' occurs in:
(a) *Salvia* (b) *Ophrys*
(c) *Nicotiana* (d) *Yucca*

*78. Which is a lepidopterous flower?
(a) Sunflower (b) *Nicotiana*
(c) *Salvia* (d) None of these

79. Pollination by bats is called:
(a) Ornithophily (b) Anemophily
(c) Malacophily (d) Cheiropterophily

80. Polysiphonous condition is found in:
(a) *Althaea* (b) Castor
(c) *Melia* (d) None of these

*81. How many nuclei are involved in double fertilization?
(MPPMT 1986)
(a) 2 (b) 3
(c) 4 (d) 5

82. No endosperm is formed in:
(a) Compositae (b) Orchidaceae
(c) Cucurbitaceae (d) None of these

83. Most common type of endosperm in angiosperms is:
(a) Nuclear (b) Cellular
(c) Helobial (d) Ruminate

84. Longest endosperm haustoria are found in:
(a) *Crotolaria* (b) *Grevillea*
(c) *Echinocystis* (d) *Ruellia*

85. Composite endosperm is found in:
(a) Compositae (b) Loranthaceae
(c) Malvaceae (d) Gramineae

86. Highest ploidy level is found in endosperm tissue of:
(a) *Thesium* (b) *Penea*
(c) *Arum maculatum* (d) *Pepromea*

*87. Aleurone cells are present in endosperm of:
(a) Cereals (b) Legumes
(c) Both (a) and (b) (d) None of these

88. Zeatin (cytokinin) is obtained from:
(a) Coconut milk (b) Cow milk
(c) Yeast extract (d) Disrupted DNA

*89. Scutellum is present in the embryo of:
(a) Pea (b) *Ranunculus*
(c) *Triticum* (d) None of these

90. The covering of radicle is called:
(a) Coleoptile (b) Scutellum
(c) Coleorrhiza (d) Epicotyl

91. Chlazosperm is present in:
(a) *Amaranthus* (b) *Portulaca*
(c) *Cyanastrum* (d) None of these

92. Tegmen in seed is derived from: **(CBSE 1990)**
(a) Inner integument (b) Outer integument
(c) Endosperm (d) Nucellus

93. 'Dust seeds' are found in:
(a) Grasses (b) Sedges
(c) Orchids (d) Cocodemur

94. If number of chromosomes in endosperm = 36, what is the number of chromosomes in root cells?
(a) 36 (b) 18
(c) 24 (d) 12

95. If no. of chromosomes in leaf cells = 24, what is the no. in integuments?
(a) 12 (b) 24
(c) 36 (d) 18

96. How many meiotic divisions are necessary to produce 100 megaspores?
(a) 25 (b) 50
(c) 100 (d) 200

97. How many meiotic divisions are necessary for formation of 400 grains in wheat?
(a) 125 (b) 250
(c) 500 (d) 400

98. Bitegmic ovules are found in:
(a) Compositae (b) Legumirosae
(c) Labiatae (d) Solanaceae

99. Albuminous dicot seed is:
(a) Maize (b) Castor
(c) Bean (d) None of these

100. Pollinia are characteristic of: **(BHU 2001)**
(a) Asclepiadaceae (b) Labiatae
(c) Compositae (d) Aristolochiaceae

101. When pollen tube enters through micropyle, then it is known as?
(a) Mesogamy (b) Microgamy
(c) Porogamy (d) Chalazogamy

102. Double fertilization is normal in: **(CBSE 1993)**
(a) Gymnosperms (b) Pteridophytes
(c) Angiosperms (d) All of these

103. Polyembryony is commonly reported in:
(a) Mango (b) *Citrus*
(c) Potato (d) Wheat

104. Seed formation without fertilization is:
(a) Apogamy (b) Apospory
(c) Apomixis (d) All of these

105. Endosperm in angiosperms is: (MPPMT 2001; CPMT 2002)
(a) Haploid (b) Diploid
(c) Triploid (d) Tetraploid

106. Pollination by wind is common in:
(a) Palmae (b) Malvaceae
(c) Solanaceae (d) Umbelliferae

107. Function of obturator on micropyle is:
(a) Obstructs the path
(b) Directs the growth of pollen tube
(c) Helps in fusion
(d) Dissolves the wall of pollen tube

108. Most primitive ovule is:
(a) Anatropous (b) Orthotropous
(c) Amphitropous (d) Hemitropous

109. Outgrowth near hilum is:
(a) Aril (b) Caruncle
(c) Nucellus (d) None of these

110. Ruminate endosperm is found in:
(a) Solanaceae (b) Aristolochiaceae
(c) Anacardiaceae (d) Gramineae

111. Term xenia was coined by:
(a) Webber (b) Focke
(c) Swingle (d) Copeland

112. Mosaic endosperm is characteristic of:
(a) Wheat (b) Maize
(c) Castor (d) *Phoenix*

113. Effect of pollen grains on the seed coat or pericarp lying outside the embryo sac is :
(a) Xenia (b) Metaxenia
(c) Pseudogamy (d) Diplospory

114. Perisperm is remaining part of: **(CPMT 1995)**
(a) Endosperm (b) Ovule
(c) Nucellus (d) Integument

115. Which of the following fruit is parthenocarpic?
(a) Mango (b) Banana
(c) Watermelon (d) Orange

116. Which structure develops into seed?
(a) Ovary (b) Ovule
(c) Egg (d) Zygote

117. How many nuclei are present in fully developed male gametophyte of flowering plants?
(a) 1 (b) 2
(c) 3 (d) 4

118. Term Apomixis was given by:
(a) Maheshwari (b) Winkler
(c) Leeuwenhoek (d) Schnarf

119. Formation of sporophyte directly from sporophytic tissue is:
(a) Apogamy (b) Apospory
(c) Diplospory (d) Parthenogenesis

120. The female gametophyte of a typical dicot at the time of fertilization is : **(CBSE 1993)**
(a) 8-celled (b) 6-celled
(c) 7-celled (d) 4-celled

121. Development of embryo sac from any cell of nucellus is called:
(a) Apogamy (b) Apospory
(c) Parthenogenesis (d) Diplospory

122. The endosperm of angiosperms is derived from:
(a) Antipodals (b) Zygote
(c) Synergids (d) Secondary nucleus

123. Pollen grain is a:
(a) Megaspore (b) Microspore
(c) Microsporophyll (d) Microsporangium

124. Circinotropous ovule is found in:
(a) *Crotolaria* (b) *Opuntia*
(c) *Pistia* (d) *Raphanus*

125. Ovule of angiosperm can be called as:
(a) Megasporangium
(b) Megagametangium
(c) Integumented megasporangium
(d) Microgametangium

126. If the inner most layer of integument becomes specialized as a nutritive layer, it is:
(a) Tapetum (b) Endothecium
(c) Endosperm (d) Endothelium

127. Tapetal cells are:
(a) Haploid (b) Polyploid
(c) Diploid (d) Triploid

128. Apomixis means development of a plant:
(a) From fusion of two gametes
(b) Without fusion of gametes
(c) From stem cuttings
(d) From root cuttings

129. If endosperm cell of a plant has 24 chromosomes, the number of chromosomes in each cell of root is:
(a) 8 (b) 16
(c) 4 (d) 24

130. Water of coconut is:
(a) Liquid nucellus
(b) Liquid mesocarp
(c) Degenerated liquid endosperm
(d) Liquid endocarp

131. The stamens represent:
(a) Microsporangia (b) Megasporangia
(c) Megasporophylls (d) Microsporophylls

132. Pollen kitt is present in pollens of:
(a) Anemophilous flowers (b) Entomophilous flowers
(c) Zoophilous flowers (d) Malacophilous flowers

133. Essential whorls of flower include:
(a) Calyx and epicalyx (b) Corolla and calyx
(c) Androecium and corolla (d) Gynoecium and roecium

134. The microsporangia in a flower are represented by:
(a) Embryo sac (b) Pollen sac
(c) Stamens (d) Carpels

135. Endosperm in coconut is:
(a) Cellular
(b) Nuclear
(c) Both cellular and nuclear
(d) Neither cellular nor nuclear

136. Meiosis in ovule takes place in:
(a) Nucellus (b) Megaspore mother cell
(c) Megaspore (d) Archesporium

137. The endosperm is ruminate if:
(a) It is fleshy
(b) It is starchy
(c) Its surface is uneven with irregularities
(d) It is oily

138. Development of embryo without fertilization is called:
(a) Adventive embryony (b) Polyembryony
(c) Parthenocarpy (d) Parthenogenesis

139. Synergids are:
(a) Haploid (b) Diploid
(c) Triploid (d) Hexaploid

140. Division of cytoplasm after meiotic division in pollen mother cell is called:
(a) Cytokinesis (b) Cytomixis
(c) Amphimixis (d) Apomixis

141. Self sterility is a term applied when:
(a) Pollen is sterile
(b) Ovule is sterile
(c) Both pollen and ovule are sterile
(d) A pollen fails to germinate on the stigma of same flower

142. When pollen tube enters through funiculus or integument, it is called: (CPMT 1991, 96)
(a) Porogamy (b) Chalazogamy
(c) Mesogamy (d) Isogamy

143. Anthesis is:
(a) Anther development
(b) Opening of flower
(c) Floral bud formation
(d) Meiosis in spore mother cell

144. Polyembryony is more frequent in:
(a) Angiosperms (b) Gymnosperms
(c) Pteridophytes (d) None of these

145. Polyembryony was first reported by Leeuwenhoek in:
(a) Mango (b) *Citrus*
(c) *Fragaria* (d) *Erythronium*

146. In adventive embryony, embryos develop from: **(AFMC 2002)**
(a) Endosperm (b) Synergids
(c) Nucellus (d) None of these

147. 5 embryos with operation of more than one methods at same time occurs in:
(a) *Citrus unshiu* (b) *Allium odorum*
(c) *Oppuntia diellinii* (d) None of these

148. Best and uniform seedlings of parental type are obtained through:
(a) Seeds- (b) Cuttings
(c) Adventive embryos (d) None of these

*149. Seminiferous plant is:
(a) Having only staminate flowers
(b) Reproducing by seeds
(c) Reproducing by vegetative propagation
(d) None of the above

150. Which is the method of inducing parthenocarpy?
(a) Application of auxins (b) Foreign pollens
(c) Withholding pollination (d) All of these

151. Concept of totipotency was given by:
(a) Steward (b) Haberlandt
(c) E. Hannig (d) Laibach

152. Best method of haploid production is: [BCECE(P.T. Exam.) 2001]
(a) Distant hybridization (b) Delayed pollination
(c) Pollen culture (d) None of these

153. Maximum success in 'androgenesis' is in:
(a) Compositae (b) Gramineae
(c) Solanaceae (d) Malvaceae

154. Best method of triploid production is:
(a) Crossing tetraploid and diploid
(b) Protoplast culture
(c) Endosperm culture
(d) None of the above

*155. Banana fruits are seedless, because:
(a) Auxins are sprayed for rapid development of fruit
(b) Vegetative propagation of plants
(c) Triploid plants
(d) Fruits are artificially ripened

156. Most important use of protoplast culture is:
(a) Obtaining rare hybrids
(b) Somatic hybridization
(c) Triploid production
(d) All of the above

157. First 'somatic hybrid' in plants was obtained by:
(a) Barski (b) Laibach
(c) Carlson (d) None of these

158. 'Cybrid' is produced in:
(a) Anther culture (b) Embryo culture
(c) Protoplast culture (d) None of these

159. Incorporation of desirable information (Genetic engineering) is possible by:
(a) Anther culture (b) Embryo culture
(c) Endosperm culture (d) Protoplast culture

*160. Virus free plants can be obtained by:
(a) Endosperm culture (b) Anther culture
(c) Meristem tip culture (d) None of these

161. Direct development of embryoids from pollen was first observed by Guha and Maheshwari in:
(a) *Ginkgo* (b) *Datura*
(c) *Raphanus* (d) *Solanum*

*162. In anther culture, some diploid plants are produced along with haploid plants, what may be the source of diploid plants?
(a) Generative cell of pollen
(b) Cells of anther wall
(c) Vegetative cell of pollen
(d) Exine of pollen wall

163. Development of embryo from unfertilized egg is called:
(a) Parthenocarpy (b) Parthenogenesis
(c) Adventive embryony (d) Polyembryony

*164. When a diploid ♀ plant is crossed with a tetraploid ♂, the ploidy of endosperm cells in the resulting seed is:
(a) Diploid (b) Triploid
(c) Tetraploid (d) Pentaploid

165. At which stage, one can distinguish between nuclear and cellular type of endosperm?
(a) Stage following division of primary endosperm nucleus
(b) Mature stage of endosperm
(c) When embryo has started divisions
(d) At heart shaped stage of embryo

166. In maize cobs, the silky hair represent: (CPMT 1991)
(a) Long styles which help in capturing the pollen grains
(b) The outgrowths of seed coat
(c) Outgrowths of spathe
(d) Outgrowth of spadix inflorescence

167. The production of gametophyte directly from sporophyte without meiosis is called:
(a) Apospory (b) Apogamy
(c) Parthenogenesis (d) Apomixis

168. The archesporium is:
(a) Single celled and situated in the centre of ovule
(b) Single celled and situated below nucellar epidermis
(c) Many celled and situated in the centre of ovule
(d) None of the above

169. Which one is correct sequence of embryo sac development?
(a) Archesporium → Megaspore → Megaspore Mother cell
(b) Archesporium → Megaspore Mother cell → Megaspore → Embryo sac
(c) Archesporium → Megaspore → Megasporophyte → Embryo sac
(d) None of the above

170. In albuminous seeds, food is stored in:
(a) Testa (b) Endosperm
(c) Cotyledon (d) Plumule

171. In cellular totipotency, roots can be induced by:
(a) Only auxins
(b) Low concentration of cytokinins and higher of auxins
(c) Higher concentration of cytokinins and low of auxins
(d) Equal concentration of both auxin and cytokinins

172. Fertilization is synonym of:
(a) Autogamy (b) Apogamy
(c) Syngamy (d) Homogamy

*173. Microspore in angiosperms contain:
(a) Two prothallial cells (b) One P. cell
(c) 3 P. cell (d) None of these

*174. Nucellar embryos are:
(a) Amphimictic diploids (b) Apomictic diploids
(c) Apomictic haploids (d) None of these

175. Crassinucellate ovule shows: (AIIMS 1990)
(a) Absence of nucellus
(b) Well developed nucellus
(c) Partially developed nucellus
(d) Ill developed nucellus

176. Which of the following plant shows distinct change from juvenile to adult phase (Topophysis)?
(a) *Solanum* (b) *Hederahelix*
(c) *Petunia* (d) Wheat

177. Which one of the following produces both enzymes and hormones?
(a) Endothecium (b) Middle layer
(c) Epidermis (d) Tapetum

178. 'Xenia' is effect of pollens on:
(a) Flower (b) Endosperm
(c) Nucellus (d) Root

179. Term 'Scion' is related to:
(a) Tissue culture (b) Protoplast culture
(c) Grafting (d) None of these

180. After penetrating stigmatic and stylar tissue, the pollen tube usually grows downwards towards egg because:
(a) No other path to follow
(b) It grows under the control of egg nucleus
(c) Attracted by dissimilar electric charge
(d) The filiform apparatus of synergids is believed to attract the pollen tube

181. Micropropagation is:
(a) Obtaining plants by tissue or cell culture
(b) Germination of seeds
(c) To produce hormones
(d) Mature stage of endosperm

182. 'Clone' is group of plants obtained through:
(a) Autogamy (b) Allogamy
(c) Hybridization (d) Vegetative propagation

183. Maximum number of antipodal cells recorded in embryo sac of Angiosperms is:
(a) 50 (b) 85
(c) 100 (d) 300

184. Normal type of sexual reproduction is:
(a) Apomixis (b) Amphimixis
(c) Pseudogamy (d) None of these

***185.** The functional megaspore undergoes:
(a) 3 meiotic divisions to form embryo sac
(b) 2 meiotic divisions to form embryo sac
(c) 3 mitotic divisions
(d) 2 mitotic divisions

186. Ruminate endosperm is found in seeds of:
(a) Compositae (b) Cruciferae
(c) Euphorbiaceae (d) Annonaceae

187. In coconut, black covering (thin layer) united with kernel around the endosperm is:
(a) Mesocarp (b) Endocarp
(c) Seed coat (d) None of these

188. Tapetum and endothecium in anther are derived from:
(a) Primary sporogenous cell
(b) Primary parietal cell
(c) Both (a) and (b)
(d) None of these

189. In a pollen grain, larger nucleus is:
(a) Generative nucleus (b) Vegetative nucleus
(c) Polar nucleus (d) None of these

190. The fibrous thickenings of endothecium are mainly made of:
(a) Cellulose (c) Pectin
(c) Lignin (d) None of these

191. Inner most layer of anther wall (tapetum) is generally derived from:
(a) Primary parietal layer
(b) Secondary parietal layer
(c) Primary sporogenous cell
(d) None of the above

192. Which is the most common type of tapetum in angiosperms?
(a) Amoeboid (b) Secretory or glandular
(c) Both (a) and (b) (d) None of these

193. Which function of tapetum is correct?
(a) Helps in pollen wall formation
(b) Transportation of nutrients to inner side of anther
(c) Synthesis of callase enzyme for separation of microspore tetrads
(d) All of the above

194. Dyad stage is formed in which type of cytokinesis during meiotic division of microspore mother cell?
(a) Successive type (b) Simultaneous type
(c) Both (a) and (b) (d) None of these

195. Old microspores separated from microspore tetrads are called :
(a) Megaspores (b) Vegetative cell
(c) Generative cell (d) Pollen grains

***196.** Male gametes or sperms are developed from generative cell by:
(a) Meiotic division (b) Mitotic division
(c) Amitotic division (d) None of these

197. Inner layer of pollen wall, *i.e.*, intine is made of:
(a) Cellulose (b) Pectocellulose
(c) Sporopollenin (d) Cutin

198. Sculpturing of exine of pollen is of great importance in:
(a) Mitotic study (b) Physiological study
(c) Taxonomic study (d) None of these

199. 'Pollen kitt' is chiefly made of:
(a) Chlorophylls (b) lipids
(c) Carotenoids (d) Both (b) and (c)

200. Megasporangium with its protective layers called integuments is called :
(a) Ovary (b) Ovule
(c) Funicle (d) Chalaza

201. Orthotropous ovule is characteristic of :
(a) Piperaceae (b) Polygonaceae
(c) Both (a) and (b) (d) None of these

202. Another name of endothelium is:
(a) Endothecium (b) Obturator
(c) Integumentary tapetum (d) Tapetum

203. Cells constituting egg apparatus as well as antipodals are:
(a) Haploid
(b) Diploid
(c) Polyploid
(d) Uninucleate and haploid

204. Pollen tube during pollen germination comes out through:
(a) Micropyle (b) Obturator
(c) Germ pore (d) Germ tube

205. Synergid cytoplasm is:
(a) Neutral (b) Strongly polarized
(c) Weakly polarized (d) None of these

206. Male gametes are finally liberated in:
(a) Nucellus (b) Ovule
(c) Embryo sac (d) Ovary

207. Nutritive role for embryo sac has been attributed to:
(a) Synergids (b) Antipodals
(c) Egg cell (d) Polar nuclei

208. Autogamy is possible:
(a) Plant is bearing bisexual flowers
(b) Both anthers and stigma mature at the same time
(c) Cleistogamy
(d) All of the above

209. Chasmogamous and cleistogamous (two types of flowers) are present in :
(a) *Helianthus* (b) *Commelina*
(c) *Rosa* (d) Cotton

210. Heterostyly as a contrivance for cross-pollination is found in:
(a) *Pennisetum* (b) *Impatiens*
(c) *Primula vulgaris* (d) *Oenothera*

211. Which of the following insects are pollinating agents?
(a) Flies (b) Bees
(c) Moths and wasps (d) All of these

212. Orchid *Ophrys speculum* is pollinated by:
(a) Sunbirds (b) *Tageticula* moth
(c) *Colpa aurea*, a wasp (d) None of these

213. Large flowers of *Strelitzia reginae* are pollinated by:
(a) Humming bird (b) Sunbird
(c) Snails (d) Moth

214. Branched pollen tubes are characteristic of:
(a) Malvaceae (b) Liliaceae
(c) Amentiferae group (d) Polygonaceae

*215. The wall of pollen tube is made of:
(a) Cellulose (b) Pectin
(c) Both (a) and (b) (d) None of these

216. Release of more than 2 male gametes inside the embryo sac is called:
(a) Heterofertilization (b) Polyploidy
(c) Polyspermy (d) Polyspory

217. Commonest nutritive tissue for developing embryo in angiosperms is:
(a) Tapetum (b) Endothelium
(c) Nucellus (d) Endosperm

218. Which type of endosperm is mostly restricted to dicots families?
(a) Nuclear (b) Cellular
(c) Helobial (d) None of these

219. Morphologically and physiologically specialized outer layers of endosperm of cereals constitute :
(a) Tapetel tissue (b) Perisperm
(c) Aleurone layers (d) Chlazosperm

*220. Main constituent of aleurone grains found in aleurone layer is:
(a) Protein (b) Phospholipid
(c) Phytin (d) Carbohydrates

221. The gametophytic generation in angiosperms is:
(a) Short-lived and simple
(b) Very long
(c) Highly complex and short-lived
(d) Not found

222. Which is not involved in apomixis?
(a) Fertilization (b) Meiosis
(c) Both (a) and (b) (d) None of these

223. Recurrent apomixis includes:
(a) Meiosis and syngamy
(b) Vegetative reproduction and agamospermy
(c) Diplospory and parthenocarpy
(d) None of the above

224. Propagules are means of:
(a) Vegetative propagation (b) Agamospermy
(c) Sexual reproduction (d) Asexual reproduction

225. A true seed is:
(a) Fertilized ovule
(b) Fertilized ovule with embryo
(c) Unfertilized ovule
(d) Fertilized ovary

226. The portion of embryonal axis between plumule (future shoot) and cotyledons is called:
(a) Hypocotyl (b) Epicotyl
(c) Coleorhiza (d) Coleoptile

*227. Exine of pollen is formed by activity of:
(a) Tapetum (b) Endothelium
(c) Middle layers (d) Endothecium

Match the following (228–232)

228. I Anemophily — A
II Cheiropterophily — B
III Ornithophily — C
IV Entomophily D
A. Wind pollination
B. Pollination by bats
C. Pollination by birds
D. Pollination by insects
(a) I-A, II-B, III-C, IV-D (b) I-B, II-C, III-D, IV-A
(c) I-C, II-D, III-A, IV-B (d) I-D, II-A, III-B, IV-D

229. I Ovary wall
II Double fertilization C
III Endosperm
IV Zygote
A. Pericarp
B. Nutritive tissue
C. Angiosperms
D. Embryo
(a) I-A, II-B, III-C, IV-D (b) I-A, II-C, III-B, IV-D
(c) I-B, II-C, III-D, IV-A (d) I-A, II-B, III-C, IV-D

230. I Polyembryony
II Apomixis
III Parthenocarpy
IV Xenia
A. Winkler
B. Leeuwenhoek
C. Focke
D. Noll
(a) I-A, II-B, III-C, IV-D (b) I-B, II-A, III-D, IV-C
(c) I-C, II-D, III-A, IV-B (d) I-D, II-A, III-B, IV-C

231. I Haploid production
II Somatic hybridization
III Triploid production
IV Adventive embryony
A. Protoplast culture
B. Endosperm culture
C. Pollen culture
D. Nucellus
(a) I-A, II-B, III-C, IV-D (b) I-B, II-A, III-D, IV-C
(c) I-C, II-A, III-B, IV-D (d) I-D, II-C, III-B, IV-A

232. I Seminiferous
II Chasmogamous
III Herkogamy
IV Homogamy
A. Flower exposing their reproductive parts
B. Seed producing plant
C. Both sex organs maturing at sametime
D. Physical barrier between male and female organs
(a) I-A, II-B, III-C, IV-D (b) I-B, II-A, III-C, IV-D
(c) I-B, II-A, III-D, IV-C (d) I-A, II-B, III-D, IV-C

233. Discovery of pollen tube was made by:
(a) Camerarius (b) Amici
(c) Strasburger (d) Schleiden

234. Micropyle in a seed is helpful in entry of:
(a) Water (b) Pollen tube
(c) Male gamete (d) None of these

235. The megasporangium on maturation in angiosperms gives rise to:
(a) Fruit (b) Seed
(c) Embryo (d) Cotyledon

***236.** Pollen grain (microspore) formation in *Cyperus* (Cypraceae) is:
(a) Very common
(b) Artificially induced by removal of anthers
(c) Similar to megasporogenesis in majority of angiosperms
(d) Similar to the microsporogenesis commonly present within angiosperms

237. The best example of polyembryony is:
(a) *Cocos* (b) *Citrus*
(c) *Capsicum* (d) *Cycas*

238. Chalazogamy is found in:
(a) *Cucurbita* (b) *Pistacia*
(c) *Casuarina* (d) *Pisum*

239. The fusion product of polars and male gamete is:
(a) Secondary nucleus
(b) Triple fusion
(c) Primary endosperm nucleus
(d) Zygote

240. Another name for secondary nucleus, which is the result of fusion of 2 polar nuclei in embryo sac is:
(a) Vegetative nucleus (b) Generative nucleus
(c) Definitive nucleus (d) None of these

241. Cells of tapetum are characterized by:
(a) Free cell formation
(b) Meiotic divisions
(c) Amitosis and endomitosis
(d) Mitosis and endomitosis

242. Which type of ovules are present in gamopetalae class of angiosperms?
(a) Tenuinucellate and bitegmic
(b) Ategmic and crassinucellate
(c) Tenuinucellate and unitegmic
(d) Crassinucellate and bitegmic

***243.** The odd one is: **(Re. Ex. CPMT 1991)**
(a) Micropyle (b) Embryo sac
(c) Nucellus (d) Pollen grain

244. In which of the following plants, water is not necessary for fertilization?
(a) *Funaria* (b) Fern
(c) *Pisum sativum* (d) *Vallisnaria*

245. The main axis of embryo is called:
(a) Tigellum (b) Hypocotyl
(c) Epicotyl (d) Scutellum

246. Which is the most logical sequence with reference to life cycle of angiosperms?
(a) Germination, endosperm formation, seed dispersal, double fertilization
(b) Cleavage, fertilization, grafting, fruit formation
(c) Pollination, fertilization, seed formation, germination
(d) Maturation, mitosis, differentiation, fertilization

***247.** Even after killing the generative cell with a laser beam, the pollen grain of a flowering plant germinates and produces normal pollen tube because:
(a) Laser beam stimulates pollen germination and pollen tube growth
(b) Laser beam does not damage the region from which pollen tube emerges
(c) The contents of the killed generative cell permit germination and pollen growth
(d) The vegetative cell has not been damaged

248. Cross-pollination can be divided into:
(a) Xenogamy and geitonogamy
(b) Autogamy and allogamy
(c) Xenogamy and autogamy
(d) Autogamy and pseudogamy

249. Styles are of type:
(a) Open (b) Half closed
(c) Closed (d) All of these

250. Which is a chemotropic agent in gynaecium?
(a) K^+ ions (b) Ca^{2+} ions
(c) Mg^{2+} ions (d) None of these

251. In monosporic embryo sacs, the functional megaspore (which develops in to embryo sac) is?
(a) Micropylar one (b) Chalazal one
(c) Both (a) and (b) (d) None of these

252. The four microspores of tetrad are joined by:
(a) Starch (b) Callose
(c) Lipid (d) Protein

253. High degree of polyploidization during development is found in:
(a) Endosperm tissue (b) Nucellus
(c) Perisperm (d) Integuments

254. Role of pollination in seed setting was first recognized by:
(a) Camerarius (b) Kolreuter
(c) Amici (d) Strasburger

255. Upto 14 pollen tubes from a single pollen have been reported in :
(a) *Malva* (b) Maize
(c) *Datura* (d) *Althaea*

256. Syngamy and triple-fusion occur:
(a) Simultaneously
(b) Triple fusion occurs more quickly than syngamy
(c) Syngamy occurs more quickly than triple fusion
(d) None of the above

257. Upto 450 mm long pollen tube is observed in:
(a) Sugarbeet (b) Maize
(c) Cotton (d) *Cucurbita*

258. The structure (ridge like) formed by fusion of funicle to main body of inverted ovule is:
(a) Chalaza (b) Raphe
(c) Hilum (d) Nucellus

*259. Tectum, baculum and foot layer are found in:
(a) Pollen wall
(b) Integuments of ovule
(c) Pollen kitt
(d) None of the above

260. 'An introduction to embryology of angiosperms' was written by: **(BCECE 2002)**
(a) Amici
(b) Nawaschin
(c) P. Maheshwari
(d) Guha and Maheshwari

261. Stamens as male organs of flowers were first reported by:
(a) Camerarius (b) Kolreuter
(c) N. Grew (d) Amici

262. Monosporic 4 nucleated embryo sac is called as:
(a) Oenothera type (b) Allium type
(c) Polygonum type (d) Adoxa type

263. The nuclei of sperm and egg fuse as a result of: **(CBSE 1990)**
(a) Base-pair relation of DNA and RNA
(b) Formation of hydrogen bonds
(c) Mutual attraction caused by differences in electrical charges
(d) Attraction of protoplasts of the egg and sperms.

264. A leaf cell of a flowering plant has 22 chromosomes, then the number of chromosomes would be:
(a) 22 in gametes (b) 11 in gametes
(c) 44 in embryo (d) 44 in a cell of stem

*265. The male gametophyte (Microgametophyte) in case of monocots is: **(CBSE 1990)**
(a) Tetrad (b) Nucellus
(c) Megaspore (d) Microspore

266. If the number of chromosomes in egg cell is 8, then what is the no. of chromosomes in endosperm? **(CPMT 1993)**
(a) 8 (b) 12
(c) 16 (d) 24

267. External water is not essential for fertilization in: **(BHU 1992)**
(a) Thallophyta (b) Bryophyta
(c) Pteridophyta (d) Spermatophyta

268. Proteinaceous endosperm of maize is called:
(a) Apophysis (b) Scutellum
(c) Aleurone layer (d) None of these

269. Part of the gynoecium which receives the pollen is called:
(a) Style (b) Stigma
(c) Ovule (d) Ovary

270. The tissue attaching the ovules with the ovary is:
(a) Placenta (b) Chalaza
(c) Funicle (d) Hilum

271. In a mature fertilized ovule *n*, 2*n*, 3*n* condition respectively are commonly found in: **(BHU 1990)**
(a) Antipodals, synergids and integuments
(b) Egg, nucellus and endosperm
(c) Egg, antipodals and nucellus
(d) Endosperm, nucellus and egg

272. The microscopic structure in a flower that contains polar nuclei is:
(a) Only gametophyte
(b) Pollen tube
(c) Embryo sac
(d) None of the above

273. Occurrence of more than four spores from a spore mother cell is called:
(a) Polysiphony (b) Polyspermy
(c) Polyspory (d) Polyembryony

274. Exalbuminous seeds store food in: **(CPMT 1996)**
(a) Endosperm (b) Cotyledons
(c) Nucellus (d) Embryo

*275. A close relation between flower and pollinating agent is best exhibited by:
(a) *Cocos* (b) *Salvia*
(c) *Yucca* (d) *Avena*

276. Seeds are called products of sexual reproduction because they: **(BHU 1991)**
(a) Give rise to new plants
(b) Are formed by fusion of gametes
(c) Can be stored for long time
(d) Are formed by fusion of pollen tubes

277. Fat is present in large quantities in the tissue of which of the following?
(a) Tuber of potato (b) Embryo of pea
(c) Endosperm of coconut (d) Fibres of cotton

278. A major application of embryo culture is in:
(a) Induction of somaclonal variation
(b) Overcoming hybridization barrier
(c) Production of alkaloids
(d) Clonal propagation.

279. After demonstration of totipotency, a botanist wants to produce identical plants from an angiospermic plant by tissue culture technique. The parts or tissue, which are likely to yield haploid embryos are:
(a) Root tips (b) Stem apices
(c) Leaves (d) Anthers

280. Which of the following is correct statement?
(a) Gametes are haploid
(b) Spores are invariably haploid
(c) Spores and gametes are invariably haploid
(d) Gametes are invariably haploid

281. How many cells or nuclei are present in male gametophyte of *Capsella*?
(a) One (b) Two
(c) Three (d) Four

282. What is true for a pollen tube?
(a) Exhibits chemotactic streaming
(b) Tip growth
(c) Cytoplasmic streaming
(d) Three non-cellular zones

283. Free nuclear divisions in an angiosperm take place during:
(a) Gamete formation (b) Endosperm formation
(c) Embryo formation (d) Flower formation

284. Early development of monocot and dicot embryo is similar upto:
(a) Dyad stage (b) Quadrat stage
(c) Octant stage (d) Globular stage

285. The fibrous thickening laid down on the endothecium is in form of:
(a) Annular rings (b) Spiral bands
(c) Radial bands (d) Tangential stripes

286. Shoot apex in monocot embryo is:
(a) At base
(b) At apex
(c) Sub-terminal in position
(d) Lateral in position

287. The endosperm of angiosperm is developed from:
(a) Zygote (b) Antipodals
(c) Synergids (d) Secondary nucleus

288. How many nuclei are present in a mature pollen?
(a) One (b) Two
(c) Three (d) Four

289. Spiny or sticky pollen grains and large attractively coloured flowers are associated with:
(a) Hydrophily (b) Entomophily
(c) Ornithophily (d) Anemophily

290. Exalbuminous seeds are seeds in which:
(a) Endosperm is present
(b) Cotyledons are absent
(c) Endosperm and cotyledons are present
(d) Endosperm is absent

291. When are cultured, another haploid pollen grain is obtained from? **(CBSE 1990)**
(a) Connective (b) Anther wall
(c) Young pollen grain (d) Tapetum

292. When pollen tube enters through micropyle, it is known as: **(CBSE 1990; CPMT 1999)**
(a) Schizogamy (b) Chalazogamy
(c) Porogamy (d) None of these

293. Which one of the following pairs of plant parts are both haploid? **(CBSE 1991)**
(a) Antipodal and egg cell
(b) Nucellus and primary endosperm nucleus
(c) Nucellus and antipodals
(d) Antipodals and megaspore mother cell

294. Syngamy means: **(CBSE 1991)**
(a) Fusion of dissimilar spores
(b) Fusion of cytoplasm
(c) Fusion of similar spores
(d) Fusion of gametes

295. Double fertilization is due to fusion of : **(CBSE 1991; CPMT 1992)**
(a) The sperm nucleus with primary nucleus
(b) The sperm nucleus with egg nucleus as well as with polar nuclei
(c) One sperm nucleus with egg and other sperm nucleus with secondary nucleus
(d) Two polar nuclei

296. Pollination is the characteristic of: **(CBSE 1991)**
(a) Pteridophytes (b) Bryophytes
(c) Fungi (d) Angiosperms

297. The embryo sac in a angiosperm is a: **(CBSE 1991, 94)**
(a) Megasporangium (b) Megaspore mother cell
(c) Megagametophyte (d) Megaspore

298. Parthenogenesis is the development of: **(CBSE 1992)**
(a) Fruit without fertilization
(b) Embryo from egg without fertilization
(c) Fruit with a harmone treatment
(d) Embryo from synergid without fertilization

299. Double fertilization was discovered by: **(CPMT 1990; MPPMT 1999)**
(a) Karl Schnarf (b) P. Maheshwari
(c) S.G. Nawaschin (d) B.G.L. Swamy

300. Ovule is inverted, its body is parallel to funicle, micropyle is near hilum, then it is called: **(CPMT 1991)**
(a) Anatropous (b) Orthotropous
(c) Amphitropous (d) Campylotropous

301. Sporogenesis means: **(CPMT 1992)**
(a) Formation of zygote
(b) Germination of seed
(c) Formation of embryo
(d) Development and formation of spores

302. A bisexual flower, which never opens is known as? **(CPMT 1992)**
(a) Autogamy (b) Cleistogamy
(c) Homogamy (d) Allogamy

303. Pollen tube moves down through style: (CPMT 1993)
(a) To affect the pollination
(b) Due to chemical attraction
(c) It is positively geotropic
(d) To obtain nourishment from the tissue of style

304. Ornithophily refers to: (CPMT 1993)
(a) Pollination by man (b) Pollination by bat
(c) Pollination by bird (d) Pollination by wind

305. A species with male and female flowers on the same plant is referred to as: (CPMT 1993)
(a) Unisexual (b) Bisexual
(c) Monoecious (d) Mioecious

306. In plants, cell of which of the following would most likely show totipotency? (CBSE 1993)
(a) Sieve tube (b) Xylem vessels
(c) Meristem (d) Cork

307. Study of formation, growth and development of a new individual generally from an egg is known as: (CBSE 1993)
(a) Cytology (b) Histology
(c) Embryology (d) Genetics

308. Haploid plants (or cells in culture) derived from microspore culture are preferred over diploids for mutation studies, because in haploids: (CBSE 1993)
(a) Recessive mutations express immediately
(b) Mutations are readily induced
(c) Haploid cells can be easily cultured
(d) Dominant mutations express immediately

309. Number of meiotic divisions required to produce 400 seeds in a pea plant is: (CBSE 1993)
(a) 600 (b) 500
(c) 800 (d) 400

310. Fertilization in which male gametes are carried through pollen tube is called: (CBSE 1994)
(a) Porogamy (b) Syngamy
(c) Siphonogamy (d) Chalazogamy

311. When pollen of a flower is transferred to the stigma of another flower of the same plant, this pollination is referred to as: (CBSE 1994)
(a) Xenogamy (b) Geitonogamy
(c) Autogamy (d) Allogamy

312. The role of double fertilization in angiosperms is to produce: (CBSE 1996)
(a) Endosperm (b) Integuments
(c) Cotyledons (d) Endocarp

*313. If there are 4 cells in anther, what will be the number of pollen grains? (CBSE 1996)
(a) 8 (b) 4
(c) 16 (d) 12

314. An embryo may sometimes develop from a cell of embryo sac other than egg, this is called: (MPPMT 1994)
(a) Parthenocarpy (b) Apogamy
(c) Apospory (d) Parthenogenesis

315. A typical anther wall has: (MPPMT 1993)
(a) Exothecium and endothecium
(b) Endothecium and tapetum
(c) Exothecium, endothecium and tapetum
(d) Exothecium and tapetum

316. In angiosperms, endosperm is formed by: (MPPMT 1993)
(a) Free nuclear divisions of megaspore
(b) Divisions of fused polar nuclei
(c) Divisions of fused polar nuclei and male gamete
(d) Divisions of fused synergids and male gamete

317. The outer wall of a pollen grain is made of: (CPMT 1993)
(a) Cellulose (b) Pecto-cellulose
(c) Lignin (d) Sporopollenin

318. The outermost layer of endosperm of maize grain is called: (CPMT 1993)
(a) Epidermis (b) Perisperm
(c) Aleurone (d) Tunica

319. In flowering plants, the male gametes are formed by the: (CPMT 1993)
(a) Generative cell (b) Vegetative cell
(c) Pollen tube (d) Uninucleate microspore

320. To produce 100 pollen grains, how many microspore mother cells are required? (CPMT 1993)
(a) 25 (b) 50
(c) 75 (d) 100

321. To produce 100 eggs, how many megaspore mother cells are required? (CPMT 1993)
(a) 25 (b) 50
(c) 75 (d) 100

322. The tapetal cells are: (CPMT 1994)
(a) Uninucleate (b) Anucleate
(c) Multinucleate (d) Dikaryotic

323. If sporophyte of sporophytic plant contain 16 chromosomes, then no. of chromosomes in a microspore mother cell will be: (CPMT 1994)
(a) 16 (b) 8
(c) 32 (d) 24

324. Development of sporophyte without fertilization from the vegetative cells of the gametophyte is called: (BHU 1994)
(a) Zygospory (b) Aplanospory
(c) Apospory (d) Apogamy

325. Germpore is the region where exine is: (MPPMT 1995)
(a) Thick (b) Uniform
(c) Thick and uniform (d) Absent

326. In angiosperms, a mature male gametophyte is derived from a pollen mother cell by: (BHU 1994)
(a) Three mitotic divisions
(b) One meiotic and two mitotic divisions
(c) Two meiotic divisions
(d) A single meiotic division

327. Tapetum is found in: (MPPMT 1994)
(a) Anther
(b) Male gametophyte
(c) Female gametophyte
(d) Microspore

328. Aleurone layer helps in: **(CPMT 1994)**
(a) Protection (b) Growth
(c) Nutrition (d) Water absorption

329. Nucellar polyembryony is seen in: **(CPMT 1994)**
(a) *Citrus* (b) *Zea*
(c) Coconut (d) All of these

330. Formation of plant from the ovum is called: **(CPMT 1995)**
(a) Apospory (b) Apogamy
(c) Amphimixis (d) Parthenogenesis

331. Totipotency in cells is: **(CPMT 1995)**
(a) Development of fruit from a flower in a culture medium
(b) Flower in a culture medium
(c) Development of an organ from a cell in culture medium
(d) Development of all tissue of all kinds from a cell in culture medium

332. If the cells of root in wheat plant have 42 chromosomes, then the no. of chromosome in the cell of pollen grain is: **(CPMT 1996)**
(a) 14 (b) 21
(c) 28 (d) 42

333. Which one of the following is triploid tissue? **(CPMT 1996)**
(a) Endosperm (b) Nucellus
(c) Synergid (d) Antipodal cell

334. Which one of the following is male gametes? **(CPMT 1996)**
(a) Megasporangium (b) Microspore mother cell
(c) Embryo sac (d) Antipodal cell

335. Stalk of the ovule is called: **(CPMT 1996)**
(a) Hilum (b) Tigellum
(c) Funicle (d) None of these

336. Fusion of dissimilar gametes is known as: **(AFMC 1996)**
(a) Fertilization (b) Dichogamy
(c) Autogamy (d) Allogamy

337. In which of the following there is no sense of parthenocarpy? **(CPMT 1996)**
(a) Banana (b) Orange
(c) Pomegranate (d) Lemon

338. In *Rafflesia*, pollination is carried by:
(a) Mites (b) Elephant
(c) Ants (d) Butterfly

339. Snails perform pollination in:
(a) *Erythrina* (b) Maize
(c) *Arisaema* (d) None of these

340. Bees are important to agriculture as they: **(CPMT 1996)**
(a) Produce wax (b) Perform pollination
(c) Prevent pollination (d) Produce honey

341. In *Kigellia pinnata* / Sausage tree pollination is performed by: **(BHU 1993)**
(a) Bats (b) Birds
(c) Insects (d) Wind

342. Growth of pollen tube towards embryo sac is: **(CPMT 1994)**
(a) Chemotaxis (b) Thigmotaxis
(c) Geotopism (d) None of these

343. Pollen kitt is necessary constituent of: **(CPMT 1994)**
(a) Exine (b) Intine
(c) Pollentube (d) None of these

344. Female gametophyte is: **(CPMT 1997)**
(a) Haploid (d) Diploid
(c) Triploid (d) None of these

345. Number of antipodals in *Polygonum* is:
(a) 3 (b) 5
(c) 2 (d) 1

346. Adventive polyembryony is common in angiosperm: **(CPMT 1997)**
(a) *Citrus* sps. (b) *Pinus*
(c) *Cycas* (d) All of these

347. Pollen tube discharges its gametes in:
(a) Synergids (b) Antipodals
(c) Central cell (d) None of these

348. An orthotropous ovule is one in which microphyle and chalaza are: **(AFMC 1998)**
(a) At right angles to funicle (b) Parallel to the funicle
(c) In straight line of funicle (d) Parallel along with ovule

349. The embryo in sunflower has: **(CBSE 1998)**
(a) No cotyledon (b) One cotyledon
(c) Two cotyledons (d) Many cotyledons

350. An interesting modification of flower shape for insect pollination occurs in some orchids in which a male insect mistakes the pattern on the orchid flower for the female of his species and tries to copulate with it, thereby pollinating the flower. This phenomenon is called: **(CBSE 1998)**
(a) Pseudoparthenocarpy (b) Mimicry
(c) Pseudopollination (d) Pseudocopulation

351. Many embryos are found in seed of: **(CPMT 1998)**
(a) *Citrus* (b) Wheat
(c) Maize (d) *Ficus*

*352. Embryo sac formation from spore is called: **(CPMT 1998)**
(a) Megasporogenesis (b) Megagametogenesis
(c) Microsporogenesis (d) Microgametogenesis

353. Development of fruit without fertilization is called: **(CPMT 1998)**
(a) Parthenogenesis (b) Parthenocarpy
(c) Heterosis (d) Oogenesis

354. Which character is most important for ornithophily? **(CBSE 1999)**
(a) Bright red coloured flowers and inflorescence
(b) White coloured funnel shaped large corolla
(c) Yellow flowers with nectaries at the base of corolla tube
(d) Scented flowers

355. Non-endospermic seeds are: **(BHU 1999)**
(a) Pea and castor (b) Pea and maize
(c) Maize and castor (d) None of these

356. If number of chromosomes in haploid cells is 5, then the number of chromosomes in endosperm of angiosperm will be: **(BHU 1999)**
(a) 5 (b) 10
(c) 15 (d) 20

357. Usual type of megaspore tetrad in angiosperms is: (CPMT 2000)
(a) Isobilateral (b) Tetrahedral
(c) Linear (d) All of these

358. Apomixis is: (CPMT 2000)
(a) Development of embryo from endosperm
(b) Development of embryo from synergids
(c) Development of embryo without meiosis and fertilization
(d) None of the above

359. If a plant is produced only vegetatively, then:
(a) No morphological and no genetical changes occur
(b) Only morphological changes occur
(c) Genetical changes are observed after two generations
(d) Both genetical and morphological changes may occur

*360. In angiosperms, female gametophyte is represented by: (MPPMT 2000)
(a) Synergids (b) Carpel
(c) Egg (d) Pollen grains

361. Which of the following is formed as a result of double fertilization? (MPPMT 2000)
(a) Endosperm (b) Megaspore
(c) Seed (d) Fruit

362. Tapetum is a part of: (MPPMT 2000)
(a) Male gametophyte (b) Female gametophyte
(c) Ovary wall (d) Anther wall

363. *Polygonum* type (normal type) of embryo sac is: (MPPMT 2000)
(a) 8-nucleate (b) 16-nucleate
(c) 24-nucleate (d) 32-nucleate

364. In a young anther, the rows of cells which later produce pollens are called: (MPPMT 1999)
(a) Antheridium (b) Archesporium
(c) Tapetum (d) Zoosporangium

365. Adventive embryony in *Citrus* is due to: (CBSE 2001)
(a) Nucellus (b) Integuments
(c) Zygotic embryo (d) Fertilized egg

366. In grasses, what happens in a microspore mother cell for the formation of mature pollen grains? (CBSE 2001)
(a) One meiotic and two mitotic divisions
(b) One meiotic and one mitotic division
(c) One meiotic division
(d) One mitotic division

367. Anemophily type of pollination is found in: (CBSE 2001)
(a) *Salvia* (b) Bottle brush
(c) *Vallisneria* (d) Coconut

368. The outermost layer of maize endosperm is known as: (Uttaranchal PMT 2001)
(a) Perisperm (b) Aleurone
(c) Tapetum (d) Endothecium

369. Developing pollen derives its nutrition from: (Uttaranchal PMT 2001)
(a) Tapetum (b) Endothecium
(c) Middle layer (d) Epidermis

370. Double fertilization is when: (Uttaranchal PMT 2001)
(a) One male gamete fuses with egg and other with synergids
(b) One male gamete fuses with egg and other with secondary nucleus
(c) Both male gametes fuse with egg
(d) Both male gametes fuse with secondary nucleus

371. Anemophily means: **(CET Karnataka 2001)**
(a) Pollination by wind (b) Pollination by birds
(c) Pollination by animals (d) Animal loving plants

*372. Formation of diploid embryo sac from diploid vegetative structure is called: **(BHU 2000)**
(a) Diplospory
(b) Apospory
(c) Adventive polyembryony
(d) Apomixis

373. In angiosperms, regarding development of microgametophyte, each microcyte (microspore mother cell) undergoes: **(BHU 2000)**
(a) Mitosis to produce 2-haploid microspores
(b) Two successive mitosis to form 4–haploid microspores
(c) Two successive meiotic divisions to form 4–diploid microspores
(d) Meiosis to produce 4-haploid microspores

374. The scutellum of grass embryo is a: **(BHU 2000)**
(a) Vestigeal organ
(b) Photosynthetic organ
(c) Absorptive organ
(d) Reserve food storage organ

375. Fragrant flowers with well developed nectaries are an adaptation for: **(BHU 2000)**
(a) Ornithophily (b) Anemophily
(c) Entomophily (d) Hydrophily

376. Pollens of anemophilous plants are: **(AFMC 2001)**
(a) Large and heavy
(b) Small and sticky
(c) Small, dry and unwettable
(d) Large, light and hygroscopic

377. Female gametophyte of an angiosperm is mostly: **(AIIMS 2000)**
(a) 7-celled (b) 8-celled
(c) 11-celled (d) Multicelled

378. Pollinia are found in which of the following plant family? **(AIIMS 2001)**
(a) Asteraceae (b) Myrtaceae
(c) Malvaceae (d) Asclepiadaceae

379. *Bignonia capreolata* is pollinated by: **(BHU 2000)**
(a) Bird (b) Wind
(c) Bat (d) Insect

*380. Cross pollination is preferred over self-pollination because: **(AFMC 2001)**
(a) It results in better offspring
(b) The new varieties are formed
(c) It is easy
(d) Parthenogenesis can be induced

381. Through which route the pollen tube enters the ovule? **(MPPMT 2001)**
(a) Chalaza (b) Micropyle
(c) Funiculus (d) Any of these

382. The point of attachment of ovule to the funicle is known as: **(MPPMT 2001)**
(a) Raphe (b) Chalaza
(c) Micropyle (d) Hilum

383. Anemophilous flowers have: **(BHU 2001)**
(a) Sessile stigma (b) Small, Smooth stigma
(c) Bright colour (d) Large, feathery stigma

384. Callus is: **(CET J & K 2002)**
(a) Material used for healing of injuries in phloem
(b) An undifferentiated mass of cells
(c) Secondary tissue developed by woody plants over a wound
(d) All of the above

385. Contrivance for self pollination is: **(CET J & K 2002)**
(a) Bisexuality (b) Homogamy
(c) Cleistogamy (d) All of these

386. In a mature seed, an aril is: **(JIPMER 2002)**
(a) A small outgrowth formed at the micropyle
(b) An outgrowth of the funicle which grows up around the ovule more or less completely enveloping the seed
(c) A persistent nucellus
(d) An outgrowth of the integuments

387. In angiosperms, triple fusion results in the formation of: **(CET Karnataka 2002)**
(a) Polar nucleus (b) Secondary nucleus
(c) Zygotic nucleus (d) Primary endosperm nucleus

388. Embryo sac is: **(BCECE 2002)**
(a) Megaspore mother cell (b) Megagametophyte
(c) Megasporangium (d) Microsporangium

389. In vegetative propagation of the tubers, which of the following remains constant through generations ? **(DPMT 2001)**
(a) Morphology, vigour and disease resistance
(b) Morphology only
(c) Vigour only
(d) Vigour and morphology only

390. When the pollens of one flower falls on the stigma of another flower of the same plant, then it is known as: **(Raj. PMT 2001)**
(a) Cleistogamy (b) Allogamy
(c) Autogamy (d) Dichogamy

391. The endosperm of angiosperm is different from that of gymnosperm because: **(Raj. PMT 2001)**
(a) Angiosperms have fats
(b) Endosperm is formed before fertilization
(c) Endosperm is not formed before fertilization
(d) It survives only for some time

392. Parthenogenesis occurs when: **(Raj. PMT 2001)**
(a) Embryo is formed without the fusion of egg and the sperm
(b) Embryo is formed by the fusion of egg and sperm
(c) Embryo is formed from another cell
(d) When sperm produces the embryo directly

393. The emasculation of flower buds is achieved by removal of: **(BHU 2002)**
(a) Sepals (b) Anthers
(c) Stigma (d) Corolla

394. Cross-pollination in crop is known as: **(BHU 2002)**
(a) Chasmogamy (b) Cleistogamy
(c) Autogamy (d) Allogamy

395. The embryo in sunflower has: **(BHU 2002)**
(a) No cotyledon (b) One cotyledon
(c) Two cotyledons (d) Many cotyledons

396. The possibility of presence of coal in an area can be guessed by the study of: **(BHU 2002)**
(a) Ecology (b) Mining the area
(c) Economic botany (d) Pollen grain analysis

397. Xenia and metaxenia terms are related with: **(AIIMS 2002)**
(a) Pollen culture (b) Only endosperm
(c) Xylem and phloem (d) Pollen and endosperm

398. What is the reason of formation of embryoid from pollen grain in tissue culture medium? **(CBSE 2002)**
(a) Cellular totipotency (b) Organogenesis
(c) Double fertilization (d) Test tube culture

399. Pollen tube releases sperms in: **(CBSE 2002)**
(a) Synergids (b) Antipodals
(c) Central cell (d) Egg

400. In due course of evolution, it is interesting to find that plants showing allogamy and their pollinators have evolved together. It is called: **(CBSE 2002)**
(a) Co-evolution (b) Mutualism
(c) Proto-cooperation (d) Commensalism

401. Covering of microspores tetrad is made of: **(CBSE 2002)**
(a) Callose (b) Pectocellulose
(c) Sporopollenin (d) None of these

402. The endosperm in angiosperms develops from: **(MPPMT 2002)**
(a) Micropylar polar nucleus
(b) Chalazal polar nucleus
(c) Secondary nucleus
(d) Zygote

403. Development of haploid plants from totipotent pollen is called : **(EAMCET 2002)**
(a) Androgenesis (b) Parthenocarpy
(c) Emasculation (d) Somatic hybridization

*404. *Gloriosa superba* is a good example of one of the following: **(EAMCET 2002)**
(a) Heterostyly (b) Cleistogamy
(c) Self sterility (d) Herkogamy

405. The term scutellum refers to: **(EAMCET 2002)**
(a) Residual nucellus of pepper seeds
(b) Single cotyledon of cereals
(c) Aril of *Trianthema*
(d) Outgrowth of pulse seeds

*406. In pulses, proteins are stored in: (EAMCET 2002)
(a) Endosperm (b) Cotyledons
(c) Pericarp (d) Seed coat

407. The haploid cell which divides by mitosis to form embryo sac is: (Raj. PMT 2002)
(a) Megaspore mother cell (b) Microspore mother cell
(c) Functional megaspore (d) Non-functional megaspore

408. Seed coat is derived from: (Raj. PMT 2002)
(a) Pericarp (b) Epicarp
(c) Integuments of ovule (d) Nucellus

409. What is pollen grain? (Raj. PMT 2002)
(a) Microspore mother cell (b) Male gamete
(c) Male gametophyte (d) Partially developed embryo

410. What real or imagined benefit is offered to potential pollinators by animal-pollinated flowers ?
(a) Food (b) Sex
(c) Nursery (d) All of these

411. What are the most abundant animals on earth which exploit every possible food resource including reproductive parts of gymnosperms?
(a) Bees (b) Beetles
(c) Moths (d) Wasps

412. What will be the gametic chromosome number of a cell, if somatic cell has 40 chromosomes? (CPMT 2003)
(a) 10 (b) 20
(c) 30 (d) 40

413. Entry of pollen tube through the chalazal end is called: (Orissa JEE 2003)
(a) Porogamy (b) Mesogamy
(c) Basigamy (d) Syngamy

414. Anemophily is pollination affected by: (Orissa JEE 2003)
(a) Water current (b) Bird
(c) Wind (d) Insects

415. Fertilization is depicted by the condition: (DPMT 2003)
(a) $n \longrightarrow 3n$ (b) $n \longrightarrow 2n$
(c) $2n \longrightarrow 4n$ (d) $4n \longrightarrow 8n$

416. Which one of the following is an endospermic seed: (Kerala PMT 2003)
(a) Pea (b) Bean
(c) Gram (d) Cashew
(e) Arecanut

417. Double fertilization is characteristic of: (Kerala PMT 2003)
(a) Gymnosperms (b) Pteridophytes
(c) Angiosperms (d) Bryophytes
(e) Thallophytes

418. The inherent capacity of a cell to regenerate a new whole organism is called: (Kerala PMT 2003)
(a) Ontogeny (b) Totipotency
(c) Phylogeny (d) Proliferation
(e) Differentiation

419. Germination of pollen grain on the stigma is: (BV Pune 2003)
(a) Autogamy (b) *In vivo* germination
(c) *In vitro* germination (d) *In situ* germination

420. In the anther wall: (BV Pune 2003)
(a) Endothecium lies inner to middle layers
(b) Middle layer lies between endothecium and tapetum
(c) Tapetum lies just inner to endothecium
(d) Tapetum lies between endothecium and middle layers

421. The aleurone layer in maize grain is specially rich in: (CBSE 2003)
(a) Starch (b) Lipid
(c) Auxins (d) Proteins

422. Pollinium is found in family: (PMET Punjab 2003)
(a) Rubiaceae (b) Myrtaceae
(c) Solanaceae (d) Asclepiadaceae

423. During the process of fertilization, when one nucleus fuses with egg and other with secondary nucleus it is called: (PMET Punjab 2003)
(a) Single fusion (b) Double fusion
(c) Single fertilization (d) Double fertilization

424. Which type of pollen grains are found in insect pollinated flowers: (AFMC 2003)
(a) Hygroscopic (b) Light and sticky
(c) Light and rough (d) Heavy and coloured

425. The raising new plants from a plant tissue through tissue culture is termed as : (AFMC 2003)
(a) Micropropagation (b) Micrografting
(c) Macroeconomic (d) Macroconsumer

426. The plant part which consists of two generations one within the otehr is : (AIIMS 2003)
(a) Germinated pollen grain
(b) Embryo
(c) Unfertilized ovule
(d) Seed

427. Which of the following pairs of plant parts are both haploid? (Manipal 2003)
(a) Nucellus and antipodal cells
(b) Antipodal cells and megaspore mother cell
(c) Nucellus and primary endosperm nucleus
(d) Antipodal cell and egg nucleus

428. An orthotropous ovule is one in which micropyle and chalaza are: (Manipal 2003)
(a) Oblique to funiculus (b) At right angles to funiculus
(c) Parallel to funiculus (d) In straight line of funiculus

ANSWERS

1—d	2—d	3—a	4—a	5—c	6—c	7—b	8—c	9—c	10—b	11—d	12—c
13—a	14—d	15—c	16—b	17—c	18—b	19—b	20—b	21—b	22—b	23—c	24—c
25—c	26—b	27—a	28—b	29—c	30—b	31—a	32—b	33—c	34—c	35—b	36—a
37—c	38—c	39—c	40—b	41—c	42—d	43—a	44—a	45—b	46—b	47—c	48—b
49—a	50—b	51—c	52—b	53—b	54—c	55—c	56—b	57—c	58—b	59—b	60—a
61—b	62—d	63—a	64—c	65—b	66—b	67—a	68—c	69—d	70—b	71—c	72—c
73—d	74—d	75—c	76—c	77—b	78—b	79—d	80—a	81—d	82—b	83—a	84—c
85—b	86—c	87—a	88—b	89—c	90—c	91—c	92—a	93—c	94—c	95—b	96—c
97—c	98—b	99—b	100—a	101—c	102—c	103—b	104—c	105—c	106—a	107—b	108—b
109—a	110—b	111—b	112—b	113—b	114—c	115—b	116—b	117—c	118—b	119—b	120—c
121—b	122—d	123—b	124—b	125—c	126—d	127—b	128—b	129—b	130—c	131—d	132—b
133—d	134—b	135—c	136—b	137—c	138—d	139—a	140—a	141—d	142—c	143—b	144—b
145—b	146—c	147—b	148—c	149—b	150—d	151—b	152—c	153—c	154—c	155—c	156—b
157—c	158—c	159—d	160—c	161—b	162—b	163—b	164—c	165—a	166—a	167—a	168—b
169—b	170—b	171—b	172—c	173—d	174—b	175—b	176—b	177—d	178—b	179—c	180—d
181—a	182—d	183—d	184—b	185—c	186—d	187—c	188—b	189—b	190—a	191—b	192—b
193—d	194—a	195—d	196—b	197—b	198—c	199—d	200—b	201—c	202—c	203—d	204—c
205—b	206—c	207—b	208—d	209—b	210—c	211—d	212—c	213—b	214—c	215—c	216—c
217—d	218—b	219—c	220—a	221—a	222—c	223—b	224—a	225—b	226—b	227—a	228—a
229—b	230—b	231—c	232—c	233—b	234—a	235—b	236—c	237—b	238—c	239—c	240—c
241—d	242—c	243—d	244—c	245—a	246—c	247—d	248—a	249—d	250—b	251—c	252—b
253—a	254—b	255—a	256—b	257—b	258—b	259—a	260—c	261—c	262—a	263—d	264—b
265—d	266—d	267—d	268—c	269—b	270—a	271—b	272—c	273—c	274—b	275—c	276—b
277—c	278—b	279—d	280—d	281—c	282—a	283—b	284—d	285—c	286—d	287—d	288—b
289—b	290—d	291—c	292—c	293—a	294—d	295—c	296—d	297—c	298—b	299—c	300—a
301—d	302—b	303—b	304—c	305—c	306—c	307—c	308—a	309—b	310—c	311—b	312—a
313—c	314—b	315—b	316—c	317—d	318—c	319—a	320—a	321—d	322—c	323—a	324—d
325—d	326—b	327—a	328—c	329—a	330—d	331—d	332—b	333—a	334—b	335—c	336—a
337—c	338—b	339—c	340—b	341—a	342—a	343—a	344—a	345—a	346—a	347—c	348—c
349—c	350—d	351—a	352—b	353—b	354—c	355—d	356—c	357—c	358—c	359—b	360—c
361—a	362—d	363—a	364—b	365—a	366—c	367—d	368—b	369—a	370—b	371—a	372—b
373—d	374—a	375—c	376—c	377—a	378—d	379—a	380—a	381—d	382—d	383—d	384—b
385—d	386—b	387—d	388—b	389—b	390—c	391—c	392—a	393—b	394—d	395—c	396—d
397—d	398—a	399—a	400—a	401—a	402—c	403—a	404—d	405—b	406—b	407—c	408—c
409—c	410—d	411—b	412—b	413—c	414—c	415—b	416—d	417—c	418—b	419—b	420—b
421—d	422—d	423—d	424—b	425—a	426—b	427—d	428—d				

EXPLANATION OF SELECTED QUESTIONS (*)

1. A staminate or male flower does not have gynoecium or pistil.
15. Ovary is the part of carpel and ovary on fertilization gives rise to fruit. Fruit wall is called pericarp.
64. Synergids, antipodals and polar nuclei may be absent in embryo sac.
78. *Nicotiana* flower is having long corolla tube, hence lepidopterous.
81. 2 nuclei are involved in syngamy and 3 in triple-fusion.
87. One or more specialized outer layers of endosperm of cereals are called aleurone layers.
89. Single cotyledon of grass embryo is called scutellum.
149. Seed producing plants are called seminiferous plants.
155. Most of banana varieties are triploid and triploidy is associated with seedlessness.
160. Shoot meristem is free of viruses and hence virus free plants can be obtained by culture of meristem.
162. Cells of anther wall are diploid.
164. Endosperm is the result of triple fusion (1 male gamete + two polar-nuclei).
173. Prothallial cell is absent in male gametophyte of angiosperms.
174. Nucellus cells are sporophytic ($2n$) and formation of embryo from these cells are apomictic (does not involve meiosis and fertilization).
185. The functional megaspore nucleus undergoes 3 mitotic divisions to form 8-nucleated embryo sac.
196. Generative cell is haploid and 2 male gametes are formed from it by mitotic division.
215. Pollen tube is formed by intine of pollen, hence made of pecto-cellulose.
220. Aleurone grains are highly protein rich grains.
227. Ubisch bodies provided by tapetum help in thickening of exine.
236. In family cypraceae, only one nucleus (out of 4) remains functional after meiotic division of microspore mother cell (similar to megaspore formation).
243. Micropyle, nucellus and embryo sac are present in ovule and hence pollen grain is odd one.
247. Pollen tube develops from vegetative or tube cell of microspore.
259. Tectum, baculum and foot-layer are sub-layers of ektexine of pollen.
265. Microspore is the beginning of male-gametophyte.
275. Obligate symbiotic relationship is present between *Yucca* flowers and moth, *Tageticula*.
313. Four microspore mother cells in anther on R.D. will give rise to 16 microspores.
352. Development of embryo sac or megagametophyte from megaspore is called megagametogenesis.
360. Egg is constant feature of female gametophyte.
372. When a diploid vegetative cell (nucellus cell) gives rise to diploid embryo sac directly, it is called apospory.
380. Crossing leads to hybrid vigour or superiority.
404. In *Gloriosa*, stigma bends in opposite direction to the stamens and thus a physical barrier (herkogamy) is there between male and female organs.
406. The seeds of pulses are non-endospermic or exalbuminous and hence proteins are stored in cotyledons.

18

Plant Anatomy

- Introduction
- Meristems or Meristematic tissue: Characteristics, classification, shoot apex organization, root apex organization
- The tissue: Simple permanent tissues (parenchyma, collenchyma, sclerenchyma), complex permanent tissues (xylem, phloem), special or secretory tissues
- Tissue system: Epidermal tissue system, ground tissue system, vascular tissue system
- Anatomy of root—General characters, orchid root, differences between dicot and monocot root, origin of lateral and adventitious roots, heteroarchy in roots, contractile roots
- Anatomy of stem: General characters, differences between anatomy of root and stem, differences between anatomy of monocot and dicot stem, Root-Stem transition
- Anatomy of leaf: Dorsiventral and isobilateral leaves and their differences, Leaf abscission or leaf fall
- Secondary growth: Secondary growth in dicot stem, annual rings (spring wood and autumn wood), heart wood and sap wood, tyloses, secondary tissue formed by cork cambium (periderm), bark, rhytidome, lenticels, secondary growth in dicot root, cork cambium activity in roots, some abnormal features

plant anatomy

Anatomy is the branch which deals with the study of **gross internal structure of plant organs as observed after section cutting.**

(*Ana* – asunder (separately) + *tamnein* – to cut).

- Study of this branch started in 1671, when **Marcello Malpighi** and **N. Grew** independently studied the anatomy of vegetable plants.
- **N. Grew** is known as **'Father of Plant Anatomy'.**

MERISTEMS OR MERISTEMATIC TISSUE

In the plant embryo, each and every cell has the capacity of continuous division, but as the plant develops from the embryo, this property of cell division is restricted to few specific regions. These regions of indefinitely dividing capacity or regions of **theoretically unlimited growth are called meristems or meristematic tissue.**

- The term meristem has been derived from a Greek word *Meristos*—which means **divisible** or **having cell division activity. So meristem is a group of cells which has power of continuous division.**

e.g., meristem at apex of stem, root, leaf primordia and vascular cambium, etc.

- The term **'meristem'** was given by **C. Nageli** (1858) for group of continuously dividing cells.

Characteristics of Meristems or Meristematics cells

1. The shape of these cells may be oval, spherical, rounded or rectangular but these are **isodiametric** (equal size).
2. These have **thin cellulosic walls.**
3. They have no intercellular spaces.
4. They take deep stain and are with large and prominent nuclei.
5. They have no reserve food material and further no ER and plastids in them.
6. Vacuole is small or absent.

Classification of Meristems or Meristematic tissue

(A) Classification on the basis of origin and development

On this basis, meristems are of 3 types:

1. Promeristem or **Procambium meristem** or **Urmeristem:** These are the regions where foundation of organs or their parts is laid down.

The primary product of the promeristem is **primary meristem.**

2. Primary meristem: These are the primary products of promeristem. These are present at the apices of root and shoot (**Apical meristems**).

- These divide in different planes.

3. **Secondary meristem :** These are formed after some growth in primary permanent tissue and give rise to secondary permanent tissue, *e.g.*, interfascicular cambium in stem, cambium in roots and also cork cambium (phellogen).

(B) Classification on the basis of position in plant body

1. **Apical meristem :** This is present at the apices of root and shoot.

- These cells divide in different planes and are **responsible for increase in length.**

2. **Intercalary meristem :** This is present away from apical meristem in primary permanent tissue. Some workers consider it as a part of apical meristem, which is separated from it by means of primary permanent tissue.

- Intercalary meristem is present at the base of **internodes**, *e.g.*, in grasses (Gramineae) or at the base **of leaves**, *e.g.*, in *Pinus* or at the **base of nodes**, *e.g.*, mint or *Mentha* (Labiatae).
- Intercalary meristem is responsible for increase in length.

3. **Lateral meristem :** It is present on the lateral sides.

- Lateral meristem divides only **periclinally** or radially and is **responsible for increase in girth or diameter.** *e.g.*, vascular cambium and cork cambium.

apices of roots & shoots -

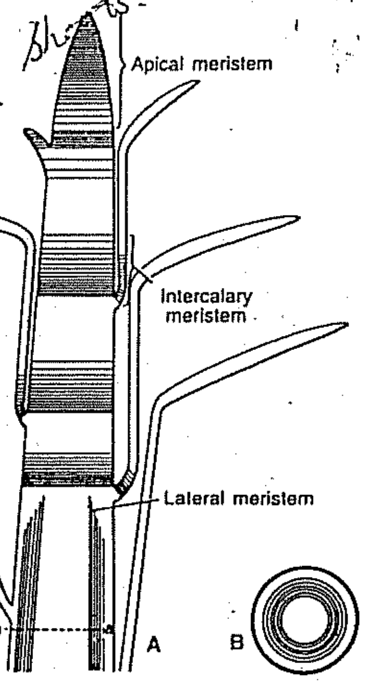

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Fig. 18.1. Different types of meristems on the basis of position in plant body

(C) Classification on the basis of plane of cell division

On this basis, meristems are of 3 types:

1. **Mass meristem :** It divides in all planes and form a mass of cells, *e.g.*, endosperm.

2. **Plate meristem :** It divides in two planes (at right angles to each other) and form a plate of cells, *e.g.*, epiblema (rhizodermis), epidermis, etc.

3. **Rib or File meristem :** It divides in a single plane and thus form a row of cells, *e.g.*, some cells of pith and cortex.

Shoot apex organization

According to Foster, Gifford and Clowes, "shoot apex is portion of shoot above the youngest primordium".

Plastochron

Time gap between two successive primordia is called plastochron, *e.g.*, if Ist primordium is formed at 7 am and IInd at 7 pm, the time gap is 12 hrs and hence **plastochron** is 12 hrs.

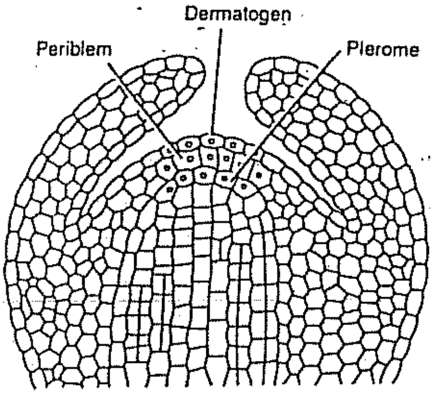


Fig. 18.2. Shoot apex organization according to histogen concept (Diagrammatic)

Theories of shoot apex organization

Different theories have been given:

1. **Apical cell theory :** This theory was given by **C. Nageli** (1858). According to this theory, there is a single apical cell with three cutting faces in the shoot apex. This theory is applicable only to some higher algae, bryophytes and vascular cryptogams (pteridophyta) and is not applicable to gymnosperms and angiosperms.

2. **Histogen concept :** This concept was given by **Hanstein** (1870). According to this concept, there are **3 groups of initials** in the shoot apex :

(a) **Dermatogen** (outermost) : Gives rise to **epidermis.**

(b) **Periblem** (middle) : Gives rise to **cortex** including endodermis.

(c) **Plerome** (innermost) : Gives rise to **vascular tissue including pith.**

Imp anticlinal v.s perix

3. **Tunica corpus concept :** This was given by Schmidt (1924). According to this concept, there are two portions in the shoot apex:

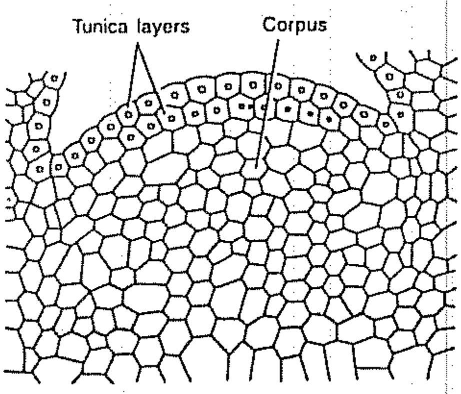


Fig. 18.3. Tunica corpus organization of shoot apex organization (Diagrammatic)

(a) **Tunica :** It is generally single layered **outer region** and it divides only **anticlinally** (only vertical division).

(b) **Corpus :** The inner mass of cells is called **corpus** and it divides both **anticlinally** as well as **periclinally**.

4. **Waiting meristem concept or Meristeme de Attente concept :** This concept was given by **Buvat** (1952). According to this, there is an inactive centre in the shoot apex which is known as **waiting meristem** and it acts as reservoir of active initials and on induction gives rise to **reproductive apex** (flower). Waiting meristem or **meristeme de attente** consists of 2 regions:

(a) **Meristeme sporogene.**

(b) **Meristeme receptacularlae.**

Root apex organization

Root apex is having simple organization as compared to shoot apex. Further **root apex is subapical** or **sub-terminal** in position because there is present **root cap (calyptrogen)** at the apex.

Different theories of root apex organization have been given as:

1. Apical cell theory

Given by C. Nageli (1858). According to this, there is single tetrahedral apical cell in the root apex. This is applicable to pteridophytes and gymnosperms and not to angiosperms.

2. Histogen concept

Given by **Hanstein** (1868). According to this concept, there are 3 groups of initials in the root apex, *i.e.*,

(a) **Dermatogen :** It gives rise to **epiblema** or **piliferous layer or rhizodermis.**

(b) **Periblem :** It gives rise to **cortex** including **endodermis.**

(c) **Plerome :** It gives rise to **vascular tissue including pith.**

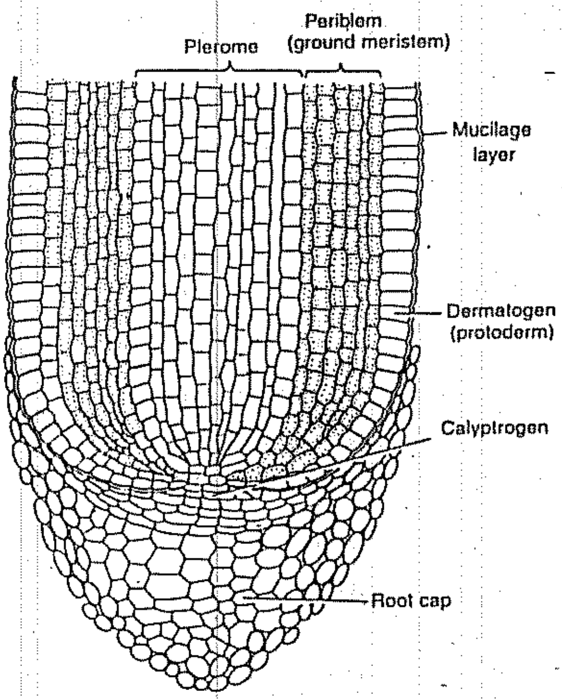


Fig. 18.4. Root apex organization according to histogen concept (Diagrammatic)

3. Quiescent centre concept

This was given by **Clowes** (1956) **in maize.** According to this, there is an inactive centre in the root apex which is called quiescent centre (having low DNA, RNA and proteins) and it acts as reservoir of active initials.

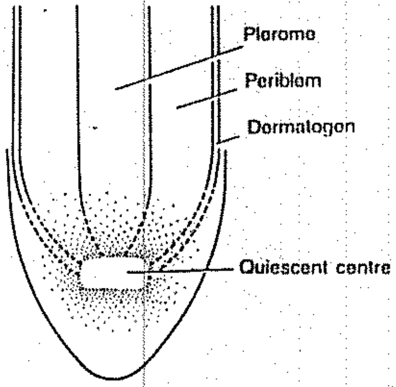


Fig. 18.5. Root apex organization according to quiescent centre concept (Diagrammatic)

⊥ Korper T Kappe

4. Korper-Kappe concept

This theory of root apex organization was given by Schuepp (1917). According to this concept, the cells of root apex divide first by transverse wall and then one of the cell divides by vertical wall. So some cells form inverted T called Korper (cap) and some cells form straight T called Kappe (base).

THE TISSUE

A group of similar or dissimilar cells which perform a common function and are similar in their origin and structure, is called a tissue.

○ Term 'tissue' was coined by **N. Grew.**

The internal structure of most of the plants is complex with the exception of some lower plants. These cells are in groups and perform definite functions.

The tissues are grouped into two main types:

1. **Meristematic tissue** (Already described).
2. **Permanent tissue.**

PERMANENT TISSUE

Permanent tissues are formed due to division and differentiation in meristematic tissue. The cells of these tissue may be **living** or **dead, thin-walled** or **thick-walled.** The thin walled tissues are generally living whereas the thick-walled tissues may be living or dead.

The permanent tissues are further of 2 types:

(A) Simple permanent tissue.

(B) Complex permanent tissue.

(A) Simple permanent tissues

The simple permanent tissue is made up of one type of cells which form a uniform system of cells and perform a common function. These simple tissues are of three main types:

(a) Parenchyma; (b) Collenchyma; (c) Sclerenchyma.

(a) Parenchyma

Term 'parenchyma' is made up of two Greek words– *para* – beside + *en-chein* – to pour, *i.e.*, some semi-liquid substance poured beside other solid tissues (ancient concept of parenchyma).

The parenchymatous cells are **isodiametric** and **thin-walled,** which may be oval, spherical or polygonal in shape with well developed **intercellular spaces.** In pericycle of some plants, parenchymatous cells become long and taper at both ends, called **prosenchyma.** (Fig. 18.6)

Functions of parenchyma

(i) The main function is storage of food. The storage parenchyma develop thick walls, *i.e.*, the endosperm of *Phoenix dactylifera* (date palm), *Coffea arabica* (coffee).

(ii) In fleshy stems and leaves, these cells act as water storage tissue, *e.g.*, *Opuntia, Euphorbia, Aloe, Agave*, etc.

(iii) In hydrophytes, the parenchyma develop air spaces and such parenchyma with air cavities is known as

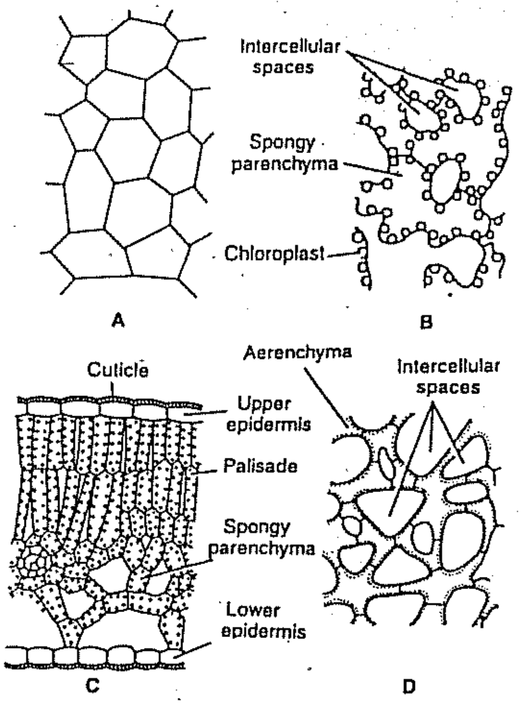


Fig. 18.6. Different types of parenchymatous tissues A. Parenchyma B. Chlorenchyma C. Palisade and spongy parenchyma D. Aerenchyma

aerenchyma, which help in floating or buoyancy, *e.g.*, *Eichhornia.*

(iv) Some times chloroplasts are developed in parenchyma cells which are called **chlorenchyma.**

(v) In some cases, the parenchyma cells develop the capacity of cell division or become cambium like, *e.g.*, **cork cambium** and **root cambium,** which help the plant in secondary growth and formation of cork.

(b) Collenchyma

Collenchyma is made of **thick-walled cells,** which are living. The thickenings are of **cellulose** and **pectin.** Further the intercellular spaces in this tissue are absent. There are 3 types of collenchyma with respect to arrangement of cells:

(i) Angular type : Here the cells are **irregularly arranged and thickenings are present at angles. This is most common type of collenchyma,** *e.g.*, in *Ficus, Vitis, Polygonum, Morus, Canabis.*

(ii) Lamellar type : Here the thickenings are **plate like.** *e.g.*, in *Rheum, Eupatorium*, etc.

(iii) Tubular type : In this type, the intercellular spaces are present, *e.g.*, in *Salvia, Malva, Althaea*, etc.

Functions of collenchyma : The chief function of this tissue is to provide **mechanical support** to the organs. Further, when the chloroplasts are present, it takes part in photosynthesis process.

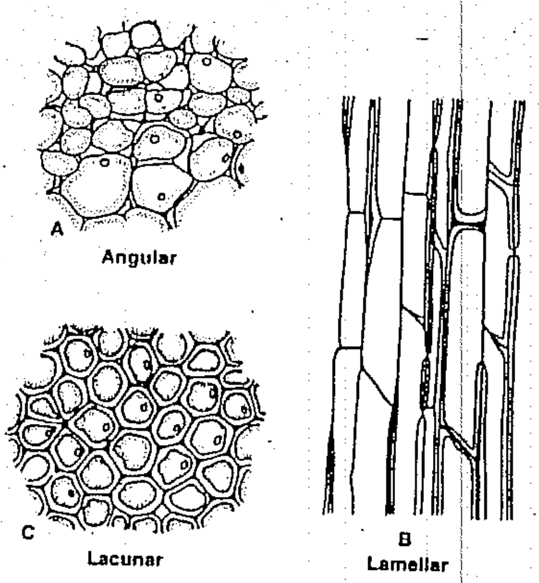


Fig. 18.7. Different types of collenchyma A. Angular B. Lamellar C. Tubular or lacunar

(C) Sclerenchyma hard.

(Greek; *Scleros* – hard).

Sclerenchyma is **thick-walled tissue** which has depositions of lignin on their cell walls (lignified).

A o These are **dead cells.**

Sclerenchymatous tissue is of 2 types:

(i) Sclerenchymatous fibres.

(ii) Sclereids or stone cells.

(i) Sclerenchymatous fibres : These are thick-walled elongated cells with tapering or pointed ends. These have thickenings of lignin and have very narrow lumen. These are dead and mechanical in function. Generally length of the fibres is upto 3 mm but in some cases like jute (*Corchorus capsularis*), flax (*Linum*) and hemp (*Canabis*), fibres are upto 20 to 550 mm in length.

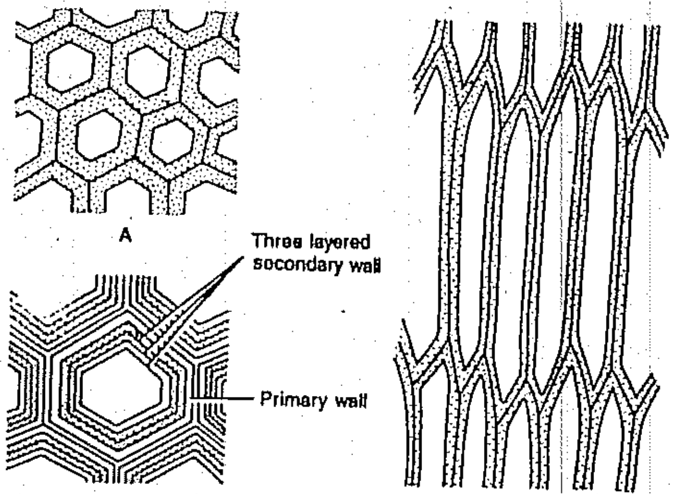


Fig. 18.8. Sclerenchyma A and B. T.S. C. L.S.

Fibres are of two types:

(a) Xylem fibres or Xylary fibres : These arise from same meristematic cells from which other xylem cells arise.

(b) Extraxylary fibres or Bast fibres : *e.g.*, **phloem fibres** (originate in phloem), **cortical fibres** (originate in cortex) and **perivascular fibres** (*e.g.*, pericyclic fibres).

(ii) **Sclereids or Stone cells :** These are not much longer than their breadth. They have also **extremely thick wall of lignin** with narrow lumen. These are isodiametric but some are elongated also.

sclerenchyma

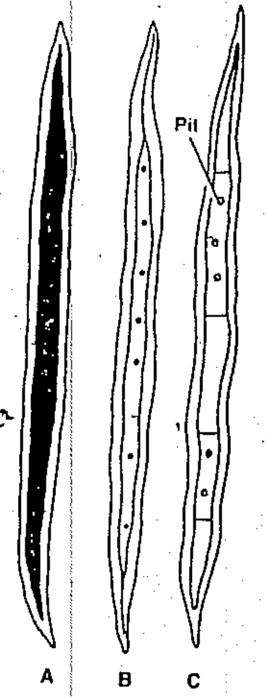


Fig. 18.9. A–C. Sclerenchymatous fibres

- Stone cells are present in **hard parts like endocarp of coconut, hard seed coats** and also in some **fruit pulp.**
- (Hardness of seed coat is due to stone cells).

These are common in cortex and pith of gymnosperms.

- Stone cells are present in the **fruit pulp** of *Pyrus.*

Stone cells may be:

(a) **Brachysclereids** (small, oval or rounded) : Found in cortex, pith and phloem of stem.

(b) **Macrosclereids** (large rod-shaped) : Found in hard seed coat of **Leguminosae** family.

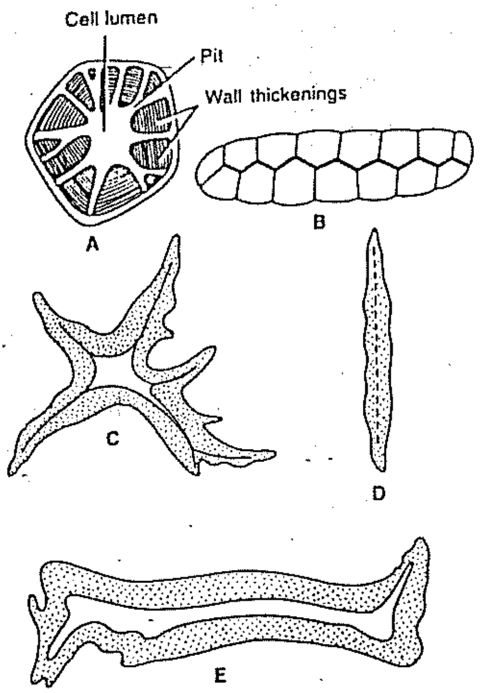


Fig. 18.10. Types of stone cells or sclereids
A. Brachysclereid B. Macrosclereid C. Asterosclereid
D. Filiform E. Osteosclereid

(c) **Osteosclereids** (bone shaped) : Found in hypodermal layers of many seeds and fruits.

(d) **Asterosclereids** (star shaped) : Found in intercellular spaces of leaves and stems of hydrophytes.

(e) **Filiform.**

- Function of sclereids is mechanical.

(B) Complex permanent tissues

A group of different types of cells which perform common function, is called complex tissue.

Important complex permanent tissues are:

(a) Xylem

Xylem is known as water conducting tissue. It is also known as **hadrome**. It is associated with conduction of water and minerals from roots to top of plants.

Xylem is having 4 types of cells or elements:

(i) **Tracheids,**
(ii) **Vessels** or tracheae,
(iii) **Xylem** parenchyma and
(iv) **Xylem** fibres.

(i) **Tracheids :** These are elongated cells with tapering ends and are dead because of deposition of **lignin** and thickenings in wall may be **scalariform** or **annular** or **reticulate** or **pitted**.

- Tracheids are generally with bordered pits.

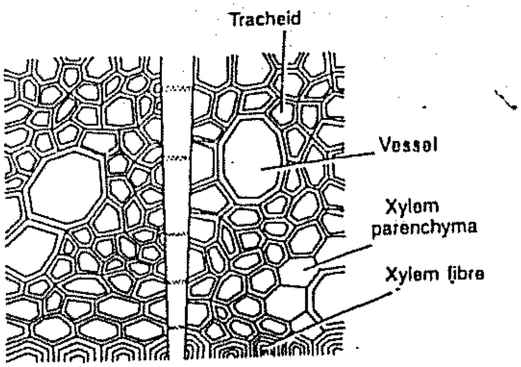


Fig. 18.11. T.S. of xylem showing its components

- Tracheids form a long row placed one above the other.
- Tracheids are single elongated cells with tapering end walls and are generally upto 1 mm, but in rare cases these may be upto 12 cm. Only tracheids form xylem of ferns and gymnosperms.

Main function of tracheids is conduction of water but due to their hard and lignified walls they also provide mechanical support.

(ii) **Vessels or Tracheae :** Vessels are different from tracheids in being cell fusion (*i.e.*, **composite structure**) as these are formed by dissolution of end walls of row of cells, *i.e.*, **vessel elements.**

- Vessels are generally upto **10 cm** in length but longest vessels are found in *Eucalyptus* and oak (*Quercus*), which are from **2 metre to 5 metre** in length.
- The walls of vessels are **lignified** but not so thick. The thickenings may be **annular** or **spiral** or **scalariform** or **reticulate**, etc.
- Usually diameter of vessels is much greater than tracheids. In most advanced types, vessels are drum-shaped with large diameter. The openings in vessel element walls are called **perforations**, which may be **simple perforations** (with single opening) or **multiple perforations** (two or more openings).

Vesselless angiosperms : Although vessels are characteristic features of angiosperms but there are certain angiosperms where vessels are **absent**. Such vesselless angiosperms belong to families:

1. **Winteraceae** (*e.g., Wintera*).
2. **Tetracentraceae** (*e.g., Tetracentron*).
3. **Trochodendraceae** (*e.g., Trochodendron*).

Besides, vessels are absent in stem and leaves of *Yucca* and *Dracaena*.

- There are some **non-angiosperms** where vessels are present, *e.g.*, some species of *Selaginella*, two species of *Pteridium*, (**pteridophytes**) and order **Gnetales** of

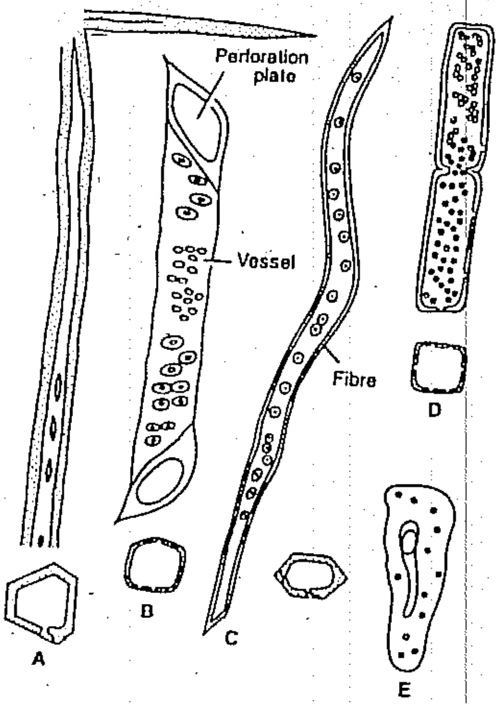


Fig. 18.12. Xylem elements A. Tracheid B. Vessel C. Fibre D—E. Parenchyma

gymnosperms (*e.g.*, *Gnetum*, *Welwitschia* and *Ephedra*).

- O At maturity **nucleus is absent in vessels.**

(iii) Xylem parenchyma : These are thin-walled living cells and they store food materials. They also help in conduction of water.

(iv) Xylem fibres or Wood fibres : They are lignified fibres found in xylem and provide **mechanical support.**

(b) Phloem or Leptome

Conducting tissue responsible for **transport of organic food is phloem.**

- In pteridophytes and gymnosperms, phloem is made of **only sieve cells and phloem parenchyma,** although in rare gymnosperms, phloem fibres are also present.
- In angiosperms phloem is made of **sieve tube elements, companion cells, phloem parenchyma and phloem fibres.** Although in many or most of the monocots, phloem parenchyma is absent.

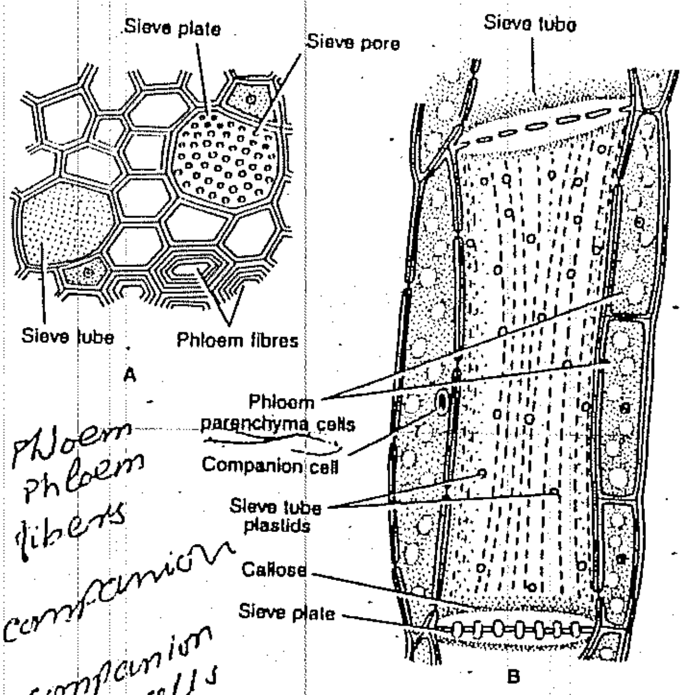
(i) Sieve tube elements : These are conducting elements of phloem. These are arranged end to end in linear rows with septa (**sieve plate**) between two sieve tube elements. In the sieve plate, there are present **sieve pores.** In **pteridophytes** and **gymnosperms,** these are not arranged in linear rows and hence called **sieve cells.**

Sieve tube elements have **thin cellulosic walls** and hence **they are living,** although in some plants, **extremely thick wall (nacre wall) is present.**

- O Sieve tube elements are **without nuclei at maturity.**
- O Sieve pores in winter get plugged with a substance called **callose** (soluble) and hence the transport of food is retarded. But in spring and summer, this callose gets dissolved and hence transport of food is rapid again.

(ii) Companion cells : These are again thin-walled cells **with distinct nucleus and hence living.**

- In primary phloem of herbaceous plants, a single companion cell is associated with a single sieve tube element whereas in phloem of woody plants, many companion cells are associated with a single sieve tube element.



Phloem
phloem
fibers
companion
companion cells

Fig. 18.13. A. T.S. of phloem showing its elements B. L.S. of phloem

- **The sieve tubes and companion cells are connected through pits.**
- **Companion cells are absent in phloem of pteridophytes and gymnosperms.**
- The companion cells help in transport of food along with sieve tubes.

(iii) Phloem fibres : These are commonly known as **bast fibres or bass.** These are thick-walled sclerenchymatous cells with tapering ends with simple pits. They provide **mechanical support.**

(iv) **Phloem parenchyma :** These are simple thinwalled parenchymatous cells (living) which are intermixed with sieve tube elements. They store food material and also help in conduction of food.

- Phloem parenchyma is absent in most of the monocots and few dicots like *Ranunculus*.

SPECIAL TISSUES OR SECRETORY TISSUES

These are responsible for secretion of different substances like **resins, tannins, gums, alkaloids, volatile oils, nectar, latex,** etc.

Secretory tissues are of 2 types:

1. Glandular tissue
2. Laticiferous tissue

1. Glandular tissue

It consists of glands and a gland is a specialized group of cells, capable of secreting some substances.

These glands are further of 2 types:

(i) External glands
(ii) Internal glands

(i) External glands : These are present on the epidermis or surface of stem or leaves, *e.g.,*

(a) **Glandular hair** as in *Urtica dioica* (Bichoo booti). Here on under surface of leaves, unicellular, silicified, calcified brittle hair are present. At the base of each hair is present a gland which secrete some poisonous substances.

(b) **Nectaries :** *i.e.,* **nectar secreting glands** in flower parts as well as in leaves of some plants. Nectar is helpful in attracting the insects for pollination. In family **Rutaceae,** nectaries are present as a disc below the ovary.

(c) **Digestive glands or Enzyme secreting glands : These are present in insectivorous plants or carnivorous plants. Such glands secrete proteolytic enzymes,** which convert protein into simple nitrogenous substances, *e.g.,* in *Drosera, Nepenthes,* etc.

(ii) Internal glands These are of many types as :

(a) Oil glands in *Citrus, Eucalyptus,* etc., are lysigenous in nature. They secrete essential oil.

(b) **Resin glands or canals :** In gymnosperms like *Pinus, Cedrus,* etc., these resin canals are present which are **schizogenous** in nature.

(c) **Water-secreting glands or hydathodes or Water-stomata :** Many plants like *Tropaeolum* (garden nasturtium), *Colocasia, Pistia* and other aroides and *Eichhornia* possess special structures, which exude impure water in the form of small drops (Guttation).

This guttation is through certain pores called **hydathodes,** which are present at the margins of the leaf. These are always open and large in size. Below the pore, there is a loose tissue called **"epithem"** and below which are present vein endings.

2. Laticiferous tissue

This tissue is mainly made of thin-walled, elongated branched multinucleate tube-like structures, which contain colourless or milky or coloured latex.

These tissues are present throughout the ground tissue of plant and contain organic substances of much importance, *e.g.,* papain enzyme (in papaya), chicle (chewing gum) in *Achras zapota,* rubber in *Hevea, Ficus,* etc.

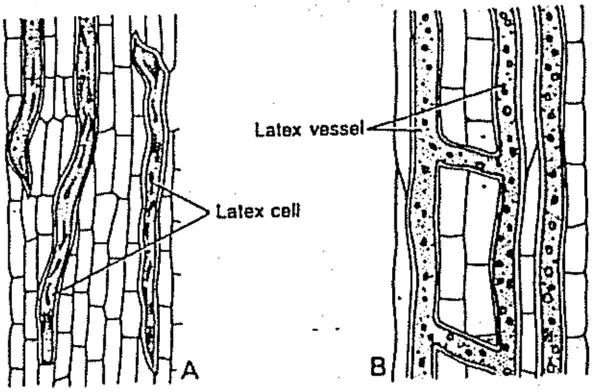


Fig. 18.14. Laticiferous tissue A. Latex cells B. Latex vessel

Various other substances like alkaloids, enzymes, tannins, proteins, etc., are also present.

Laticiferous tissue is of 2 types:

(i) Latex cells
(ii) Latex vessels

(i) **Latex cells :** These are **individual cells which get branched but don't anastamose,** *e.g.,* in *Calotropis, Nerium, Vinca, Thevetia* and *Euphorbia,* etc.

(ii) **Latex vessels :** These are made of number of cells joined together by dissolution of septa, get branched and ultimately anastamose, *e.g.,* in *Papaver, Argemone* (yellow latex).

- In *Hevea* (rubber), these laticifers occur in **secondary phloem** and in papaya, both in **xylem and phloem.**

TISSUE SYSTEM

All the plant tissues which perform same common function, irrespective of their position in the body, constitute tissue system.

There are 3 main tissue systems in plant body:

1. Epidermal tissue system
2. Ground tissue system
3. Vascular tissue system

1. Epidermal tissue system

It forms outer covering of plant, which is in direct contact with external environment.

- Epidermis is made of 2 Greek words, *i.e., Epi* means upon + *derma* means skin and hence it is a continuous outer layer interrupted by stomata or lenticels.
- Generally epidermis is single layered, but in certain leaves, multi-layered upper epidermis is present, *e.g.,* in *Ficus, Nerium, Pepromea,* etc.

- These cells perform different functions like **protection, absorption, excretion, gaseous exchange, secretion** and **control of transpiration, etc.**
- Epidermal cells are living and generally don't possess chloroplasts except shade plants (**sciophytes**), **hydrophytes** and some ferns, etc. Further chloroplasts are present in **guard cells** (specialized epidermal cells).
- Epidermal cells also possess **anthocyanin** pigments, **tannins** and different **crystals.**
- The outer wall of epidermal cell is thickest, inner is thinnest and radial walls are thick above and thin below.
- In some grasses on epidermis, there are some larger, **thin-walled cells** with vacuoles called **bulliform cells** or **motor cells** or **bubble like cells,** which in dry conditions loose water and thus the rolling up of leaves occurs, *e.g.,* in *Psamma, Poa, Agropyron, Amophilla,* etc.

Stomata : The stomata are minute pores which occur on epidermal surface of leaves and also some herbaceous stems. Each stoma or pore is bound or guarded by two specialized **kidney shaped or bean shaped** epidermal cells, called **guard cells.** The guard cells are also surrounded by other specialized epidermal cells called subsidiary cells or accessory cells.

- In some monocots like **doob grass** (*Cynodon dactylon*) and **maize,** etc., guard cells are **dumb-bell** or **barbell-shaped.**
- The guard cells are living and **contain chloroplast.**
- In **dicot leaves,** stomata are **scattered** whereas in **monocots,** these are **arranged in rows.** Further in **dicots** these are present generally on **lower epidermis** whereas in **monocots,** on **both surfaces.**
- In **free floating hydrophytes,** stomata are present on **upper epidermis,** whereas in **submerged hydrophytes,** these are **absent** or **non-functional** (in **algae and fungi, stomata are totally absent**).
- Number of stomata per sq. mm of leaf is 14 to 1038 (general number is 50–300 per sq. mm). On per square cm basis, the number varies from 1000–60,000 in different species. When fully open, they occupy **only 1 to 2%** of total leaf area.

In dicots four main types of stomata are present :

(a) Anomocytic or Ranunculaceous type : Here around the guard cells, number of subsidiary cells is 5.

(b) Anisocytic type or Cruciferous type : Here number of subsidiary cells is 3 and one subsidiary cell is clearly smaller than other two cells.

(c) Paracytic type or Rubiaceous type : Here number of subsidiary cells is 2 and these two cells are parallel to long axis of guard cells.

(d) Diacytic type or Caryophyllaceous type : Here number of subsidiary cells is 2 and these are at **right angles** to guard cells.

- In xerophytes, stomata are of **sunken type** so as to reduce water loss by transpiration.
- Stomata help in **gaseous exchange** and also help in **controlling transpiration.**

Trichomes

Trichomes are various **unicellular** or **multicellular** appendages from epidermal cells and these are found in all plant parts. These may be **stellate** or **glandular** or **floccose** type, etc.

- Trichomes help in **checking excess loss of water** and secondly provide **protection.**

2. Ground tissue system

The tissue present between epidermis and vascular tissue system constitute ground tissue system. The different components of this system are :

(i) Hypodermis

Generally one or two layers of continuous or discontinuous tissue present below epidermis, is called **hypodermis.**

- **In dicot stem,** hypodermis is **collenchymatous** and in **monocot stem, sclerenchymatous.**

It is **protective** in function.

(ii) General cortex

It is few to many layered thick and in most of the cases, it is thin-walled and parenchymatous with intercellular spaces.

The cells of cortex **contain starch grains, oil, tannins** and crystals of various types.

- Sometimes in young stem, **chloroplasts** develop in cortical cells, which is called **chlorenchyma.**

In **hydrophytes,** cortex is **aerenchymatous** (with air cavities).

- General function is **storage of food** and also **mechanical support.**

(iii) Endodermis (Starch sheath)

Endodermis is single layered structure which separates cortex from stele.

- The cells of endodermis are **barrel-shaped** without **inter-cellular spaces, living** and **containing starch.** (Hence it is known as starch sheath).

- Radial and tangential walls of endodermal cells possess thickenings of **lignin, suberin and cutin** in the form of **strips or bands,** which are known as **casparian bands** or **casparian strips** (as were discovered by **Caspar).**
- A well defined endodermis is constant feature of **roots** (not in stem).
- There are **thick-walled** and **thin-walled** cells in endodermis and **thin-walled cells** are known as **passage cells** or **transfusion cells,** which are present **opposite the protoxylem** groups.

Functions : (a) **It acts as water-tight layer** between vascular and non-vascular regions.

(b) Stores starch.

(c) Serves as **protective layer.**

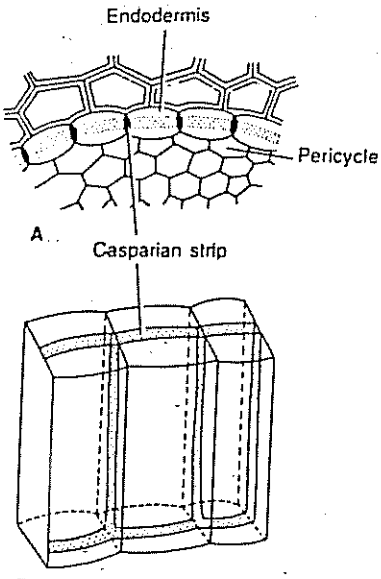


Fig. 18.15. Endodermis A. Cross section
B. 3-D view showing casparian strips

(iv) Pericycle

It is single or few layered cylinder of thin-walled parenchymatous or rarely thick-walled sclerenchymatous cells inside the endodermis.

In *Smilax* root, pericycle is **multilayered** and **sclerenchymatous.**

- In some cases like **sunflower** stem, pericycle is **heterogenous,** *i.e.,* composed of thick-walled and thin-walled cells.
- Pericycle is present in most of the roots except in roots of parasitic plants and hydrophytes.
- Thick-walled pericycle is **mechanical** in function whereas thin-walled pericycle is storage in function.
- In angiosperms, **pericycle gives rise to lateral roots.**

(v) Pith or Medulla

(No in Monocot stem)

It constitutes central portion in **dicot stem** as well as in **monocot** and **dicot roots.** It is generally having thin-walled parenchymatous cells, which help in storage.

- o From the periphery of pith, between the vascular bundles, there are present **medullary rays or pith rays** in dicots, connecting pith and pericycle and help in radial translocation of food materials.

3. Vascular tissue system

Central column of axis (root and stem) is called stele, which is made of number of vascular bundles, which constitute vascular tissue system.

- The vascular bundle is having xylem, phloem and cambium (if present).
- Xylem may be exarch or endarch.
  - o In **roots** xylem is **exarch** or **centripetal,** *i.e.,* protoxylem or first formed xylem is towards periphery.
  - o In **stem,** xylem is **endarch** or **centrifugal,** *i.e.,* protoxylem is towards centre (pith).

Types of vascular bundles

Mainly vascular bundles are of 3 types:

(i) Radial
(ii) Conjoint
(iii) Concentric.

(i) Radial vascular bundles : When xylem and phloem patches or strands are present at different radii, such type of vascular bundles are known as **radial.** Radial vascular bundles are the characteristic feature of **roots.**

(ii) Conjoint vascular bundles : When xylem and phloem are present on the same radius, this type of vascular bundles are known as **conjoint.** Conjoint vascular bundles are the characteristic feature of **stem.**

- o In dicot stem, vascular bundles are **conjoint, collateral and open.**

Collateral—When phloem is present on one side (outerside) of xylem.

Open—When cambium is present between xylem and phloem.

- o In monocot stem, vascular bundles are **conjoint, collateral and closed.**

Closed—When no cambium is present between xylem and phloem.

Bicollateral— When phloem patches are present on both sides of xylem, it is called **bicollateral vascular bundle.** Here, there are two cambium rings.

- o Bicollateral vascular bundles are found in families **Cucurbitaceae, Solanaceae and Myrtaceae.**

(iii) Concentric vascular bundles : When xylem surrounds phloem completely or phloem surrounds xylem completely, such vascular bundles are called **concentric.** These are of two types: (Fig. 18.16)

(a) Amphicribal or Hadrocentric vascular bundles : When xylem is surrounded by phloem on all sides, such vascular bundles are called **amphicribal** or **hadrocentric** (*i.e.,* hadrome or xylem in centre). Such vascular bundles are found in **ferns.**

(b) Amphivasal or Leptocentric vascular bundles : When phloem is surrounded by xylem on all sides, such vascular bundles are called **amphivasal** or **leptocentric** (*i.e.,* leptome or phloem in centre). Such vascular bundles are found in *Yucca* and *Dracaena.*

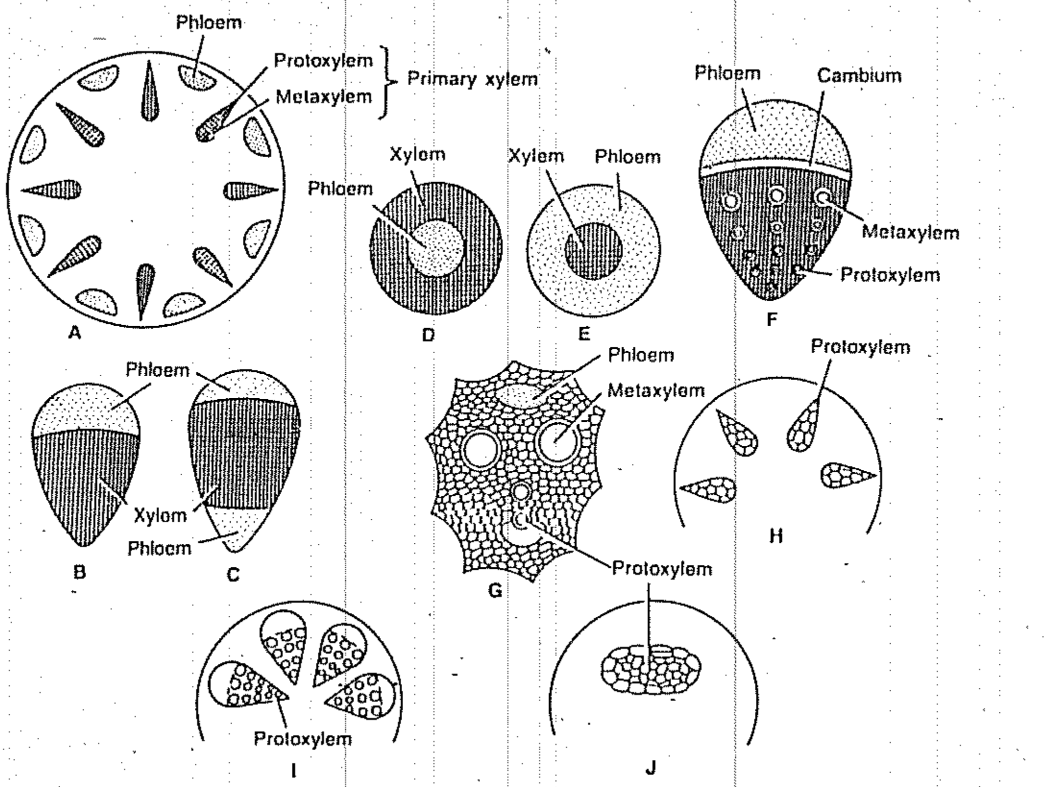


Fig. 18.16. Different types of vascular bundles A. Radial B. Conjoint collateral C. Conjoint bicollateral D. Amphivasal (concentric) E. Amphicribal (concentric) F. Open V.B. G. Closed V.B. H. Exarch or centripetal xylem I. Endarch or centrifugal xylem J. Mesarch xylem

ANATOMY OF ROOT

Main characters of root anatomy are:

1. On outer side, there is single layered **epiblema** or **piliferous layer** or **rhizodermis**, which bears **unicellular root hairs.**

- Cuticle and stomata are absent.

(Root hair arise from epiblema).

2. Inner to epiblema is multilayered cortex. Starch sheath

3. Inner to cortex is present single layered distinct **endodermis** or **starch sheath** with distinct **casparian strips** or **bands.**

4. Inside the endodermis, there is present distinct **pericycle.**

5. Vascular bundles in root are **radial.**

6. **Xylem** is **exarch** or **centripetal.**

7. Phloem is made of sieve tubes, companion cells and phloem parenchyma.

○ (Phloem parenchyma is absent in monocot root).

8. In the centre, pith is well developed or ill defined.

Orchid root

In the aerial roots of orchids, in outer portion is present multilayered **velamen** tissue, which is made of large, dead cells with fibrous thickenings. These contain air in dry conditions and **absorb moisture** when atmosphere is wet. Outermost layer of velamen is **limiting membrane** having cuticle and inner to velamen is **exodermis** (outermost layer of cortex), which is having **thick** and **thin-walled** cells. Thin-walled cells are called **passage cells.** (Fig. 18.17)

Differences between dicot and monocot root

	Dicot root	Monocot root
1.	**Diarch to hexarch condition,** *i.e.,* **vascular bundles are 2 to 6.**	**Polyarch condition,** *i.e.,* **more than 6 vascular bundles.**
2.	Pith is less developed or absent.	Well developed pith is present.
3.	Cambium is formed late during secondary growth.	Cambium is not formed.
4.	Pericycle forms lateral roots and lateral cambium.	Pericycle gives rise only to lateral roots.

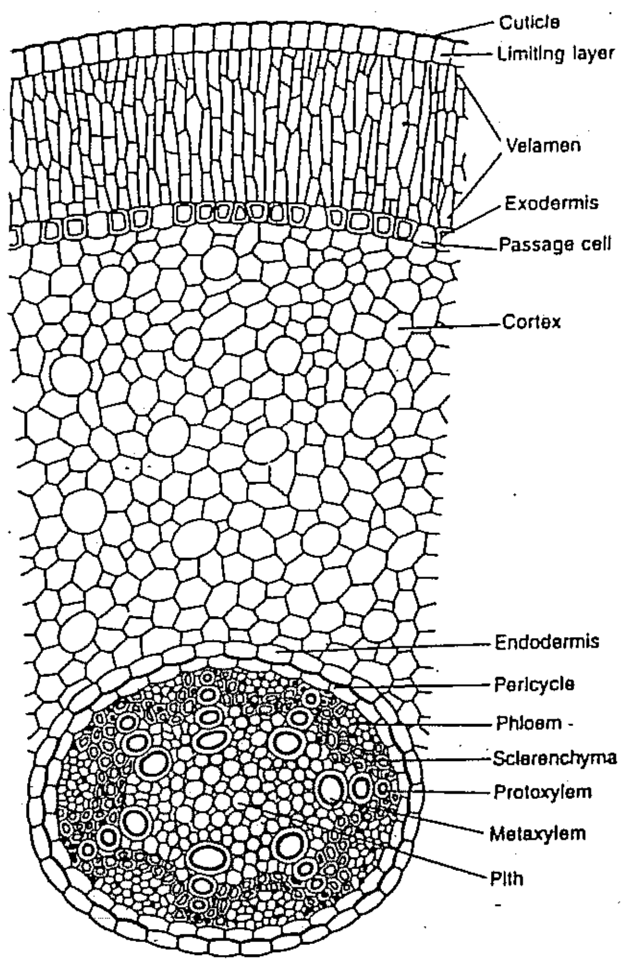

Cuticle
Limiting layer
Velamen
Exodermis
Passage cell
Cortex
Endodermis
Pericycle
Phloem
Sclerenchyma
Protoxylem
Metaxylem
Pith

Fig. 18.17. T.S. of orchid root (aerial) showing velamen tissue

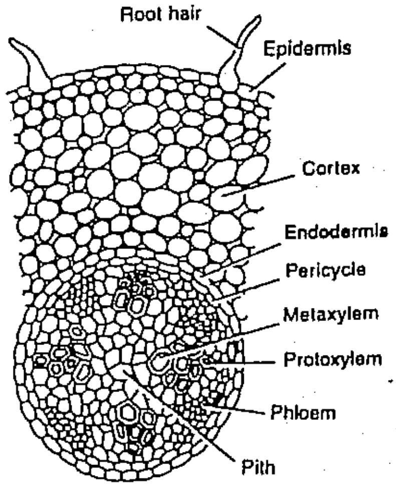

Root hair
Epidermis
Cortex
Endodermis
Pericycle
Metaxylem
Protoxylem
Phloem
Pith

Fig. 18.18. T.S. of typical dicot root (a portion)

- **Conjunctive tissue :** The tissue between xylem and phloem strands in root is called **conjunctive tissue.**

Origin of lateral roots

Origin of lateral roots is endogenous, *i.e.*, deep seated and arise from pericycle.

Origin of adventitious roots

The roots which arise from the tissue or organ other than radicle (*i.e.*, from hypocotyl, stem or its branches, etc.) are called adventitious roots.

- Origin of adventitious roots is from pericycle or cortex, *i.e.*, deep seated.

Heteroarchy in roots

In some plants, roots of different arches are present in the same plant and such roots are called **heteroarchic roots** and this phenomenon is known as **heteroarchy.**

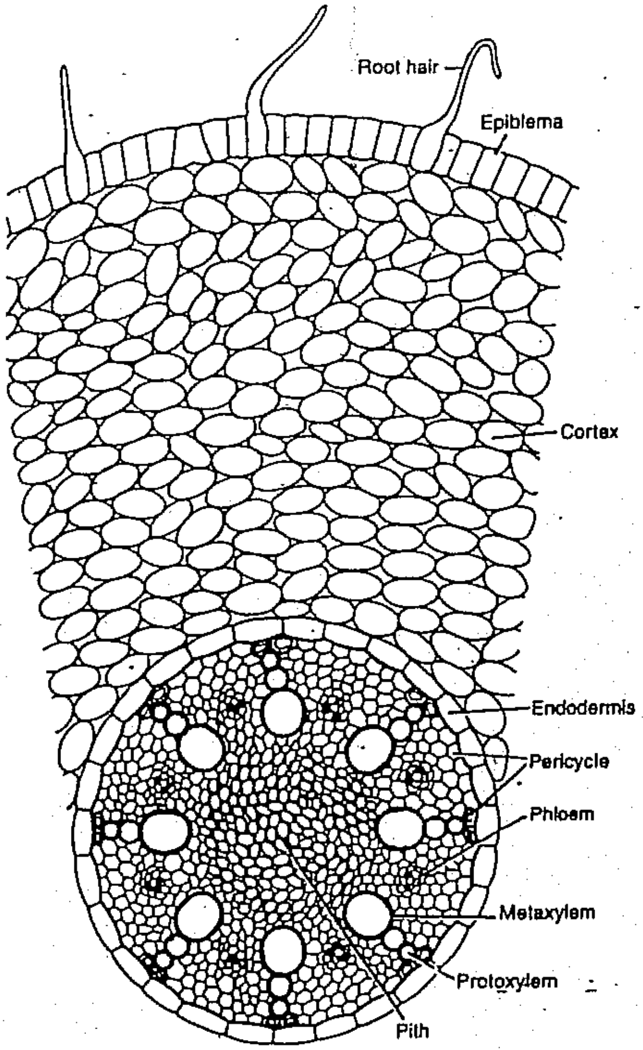

Root hair
Epiblema
Cortex
Endodermis
Pericycle
Phloem
Metaxylem
Protoxylem
Pith

Fig. 18.19. T.S. of typical monocot root (a portion)

e.g., Wardlaw (1928) reported phenomenon of heteroarchy in *Nymphaea chilensis*.

Here,

Young roots — Tetrach (4 arches)
Slightly mature roots — 7 arches
Still more mature roots — 12–14 arches
Most mature roots — 16–18 arches

Similarly, in *Eryngium* (Umbelliferae), *Enhydra* (Compositae), heteroarchy is present.

Contractile roots

Roots of certain herbaceous dicots and monocots show wrinklings on their surface at maturity and such roots with wrinklings on their surface are known as **contractile roots**.

e.g., *Medicago*, *Daucus*, *Trifolium*, *Crinum*, *Allium*, *Gladiolus*, etc.

ANATOMY OF STEM

Chief characteristics of stem anatomy are:

1. Cuticle is usually developed.
2. Hairs are **multicellular.**
3. Vascular bundles are **conjoint, collateral** or **bicollateral** or even **concentric.** Further vascular bundles may be **open** or **closed.**
4. Xylem is **endarch** (centrifugal), *i.e.*, protoxylem is towards pith and metaxylem towards periphery.

Differences between anatomy of root and stem

	Root	Stem
1.	Outer layer is **epiblema** or piliferous layer or rhizodermis without cuticle.	Outer layer is epidermis and usually with cuticle.
2.	Root hairs are **unicellular.**	Hairs are **multicellular.**
3.	Chlorenchyma is absent in root (*i.e.*, parenchyma with chlorophyll is absent).	In young stem usually **chlorenchyma** is present. However, absent in mature stem.
4.	**Endodermis** or starch sheath is well developed.	Endodermis is usually ill developed.
5.	Vascular bundles are **radial.**	Vascular bundles are **conjoint, collateral** or **bicollateral** or **concentric.**
6.	Xylem is **exarch or centripetal.**	Xylem is **endarch** or **centrifugal.**

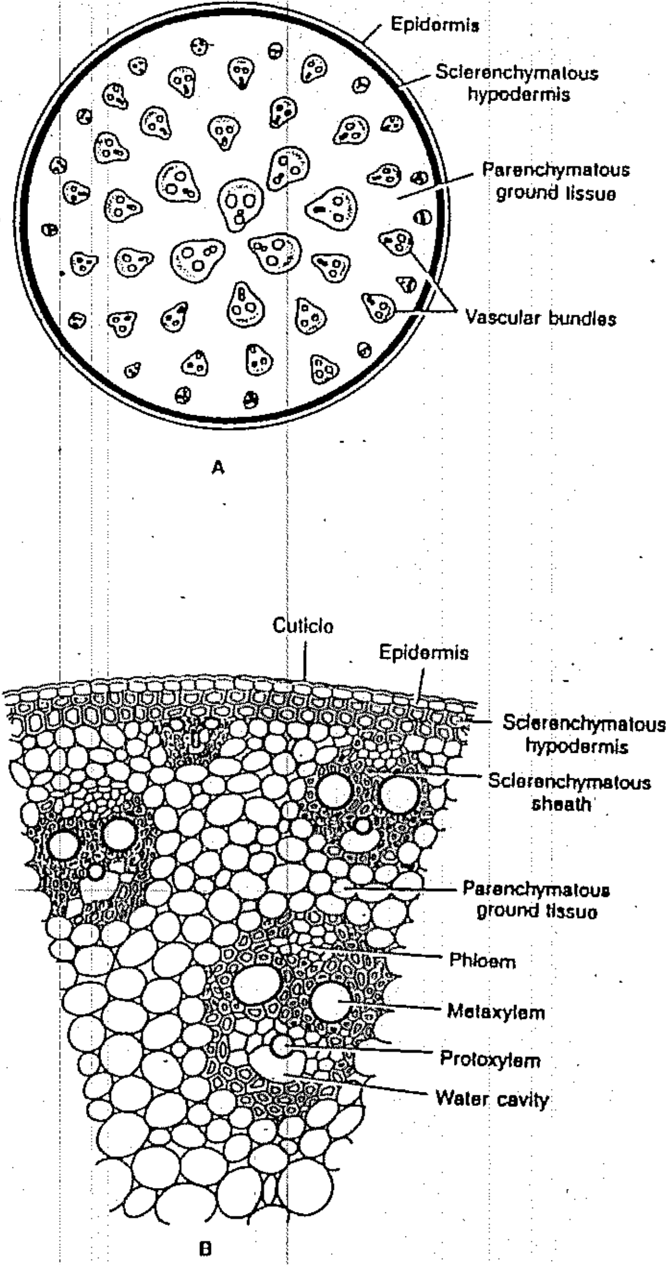

Epidermis
Sclerenchymatous hypodermis
Parenchymatous ground tissue
Vascular bundles
A
Cuticle
Epidermis
Sclerenchymatous hypodermis
Sclerenchymatous sheath
Parenchymatous ground tissue
Phloem
Metaxylem
Protoxylem
Water cavity
B

Fig. 18.20. Monocot stem (maize)
A. T.S. diagrammatic
B. A portion magnified

Differences between anatomy of monocot stem and dicot stem

	Monocot stem	Dicot stem
1.	Epidermis with generally comparatively smaller cells.	Epidermis is made of comparatively larger cells.
2.	Hairs are generally absent.	Multicellular hairs are present.
3.	Hypodermis is sclerenchymatous.	Hypodermis is collenchymatous.
4.	Cortex is generally absent, but from hypodermis to centre of stem there is present ground tissue.	Cortex is made of many layered parenchymatous cells.
5.	Endodermis is absent.	Endodermis is present but usually poorly developed.
6.	Pericycle is absent.	Pericycle is made of one or many layers of cells.
7.	Medullary rays are absent.	Medullary rays are present between vascular bundles.
8.	Pith is absent.	Pith is present.
9.	Vascular bundles:	
	(a) Scattered V. B.	(a) V. B. are arranged in a ring.
	(b) V.B. are conjoint, collateral and closed.	(b) V.B. are conjoint, collateral and open.
	(c) There is difference in the size of V. B. in the centre and at periphery, *i.e.*, V. B. in centre are larger in size and towards periphery are smaller.	(c) V. B. are of same size.
	(d) Bundle sheath is present around vascular bundle in monocot stem.	(d) Bundle sheath is absent.
	(e) Oval vascular bundles.	(e) Wedge shaped vascular bundles.
	(f) Phloem parenchyma is absent.	(f) Phloem parenchyma is present.
	(g) Xylem vessels are 'Y' or 'V' shaped.	(g) Xylem vessels are radial.

Root-Stem transition

The embryonal axis or tigellum has **radicle** on one end and **plumule** on the other end, which give rise to root and shoot respectively. In **root**, there is **radial arrangement** of xylem and phloem strands and further xylem in root is **exarch** (*i.e.*, protoxylem towards periphery). In **stem**, vascular bundles are **conjoint** and **collateral** and xylem is **endarch** (*i.e.*, protoxylem towards centre). Inspite of these differences in arrangement, vascular continuity is maintained between root and shoot. The change from exarch condition of xylem in root to endarch condition in stem occurs in a specific region of axis, called **transition zone** or **transition region**.

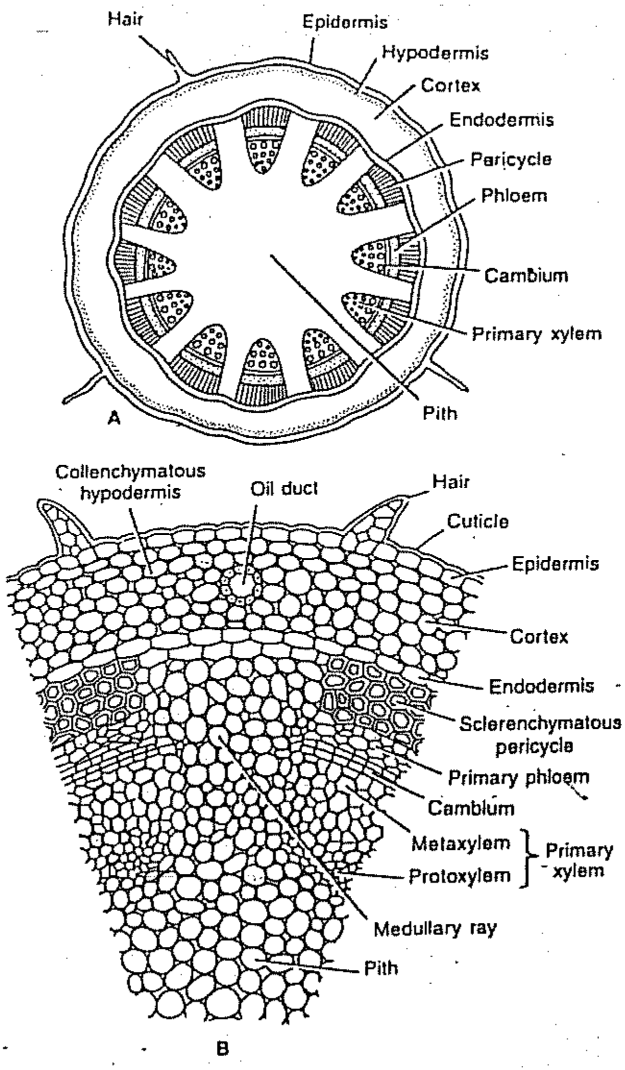

Hair
Epidermis
Hypodermis
Cortex
Endodermis
Pericycle
Phloem
Cambium
Primary xylem
Pith
A
Collenchymatous hypodermis
Oil duct
Hair
Cuticle
Epidermis
Cortex
Endodermis
Sclerenchymatous pericycle
Primary phloem
Cambium
Metaxylem
Protoxylem
Primary xylem
Medullary ray
Pith
B

Fig. 18.21. Dicot stem (sunflower) A. T.S. diagrammatic B. A portion magnified

- It is generally **hypocotyl region** (at base, near its middle or in upper part) in which this change or transition occurs.
- The length of this transition region varies from **less than a mm to few centimetres** (depending upon species).
- Generally this region is very short in **monocotyledons.**

ANATOMY OF LEAF

On the basis of anatomy, leaves are of 2 types:

1. Dorsiventral leaves
2. Isobilateral leaves

1. Dorsiventral leaves

These are found in **dicots**. These are generally **horizontal** and sunlight falls on their upper surface (ventral surface or adaxial surface).

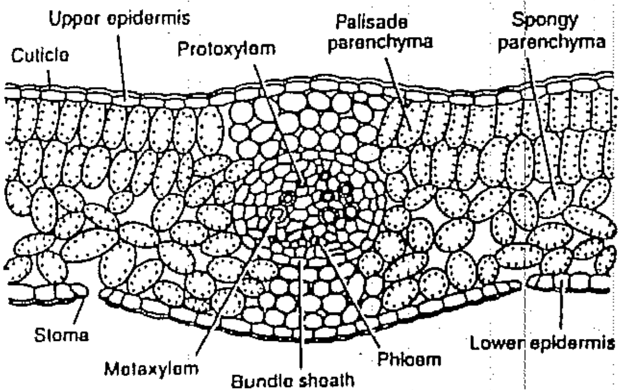


Fig. 18.22. T.S. of a dorsiventral leaf

The important anatomial features of dorsiventral leaves are:

(i) Upper epidermis

This is generally single layered outermost layer made of parenchymatous cells but sometimes multilayered upper epidermis is present, *e.g.*, in *Ficus, Piper, Nerium* as well as *Begonia.* Cuticle is well developed on upper epidermis..

The epidermal cells have sometimes out growths called **papillae**, *e.g.*, in *Gladiolus.*

The epidermal cells are devoid of chloroplast and further stomata are usually absent on upper epidermis.

(ii) Lower epidermis

It is just like upper epidermis but here stomata are present (*i.e.*, dorsiventral leaves are **hypostomatic**).

Chloroplasts are also absent in lower epidermis except guard cells of stomata. Below the stomata are present sub-stomatal cavities, which help in gaseous exchange.

(iii) Mesophyll

In between upper and lower epidermis is present mesophyll tissue, which is divided into 2 regions:

(a) **Palisade parenchyma:** These are elongated columnar cells **without intercellular spaces.** These have chloroplast in them and generally arranged in 2 layers.

(b) **Spongy parenchyma** is found below palisade parenchyma and are spherical or oval **with intercellular** spaces.

These have also chloroplast but number of chloroplasts is more in palisade parenchyma than spongy parenchyma.

Intercellular spaces are connected to sub-stomatal cavity and hence stomata, which help in gaseous exchange.

(iv) Vascular bundles

Vascular bundles are found scattered in spongy parenchyma and the V. B. in midrib region is largest.

- Vascular bundles are **conjoint, collateral** and **closed.** Each V.B. is surrounded by a bundle sheath of parenchymatous cells.
- In the V. B., xylem is present towards upper epidermis and phloem towards lower epidermis. Further in xylem, protoxylem is towards upper epidermis.
- Xylem consists of vessels or tracheae, tracheids, xylem parenchyma and xylem fibres and is meant for conduction of water and minerals.
- Phloem is made of sieve tubes, companion cells, phloem parenchyma and phloem fibres.

Above and below the largest V.B., there are present parenchymatous or collenchymatous mass of cells which do not contain chloroplast.

2. Isobilateral leaves

These are found in **monocots** and are generally **vertical.** In transverse section, following structure is seen:

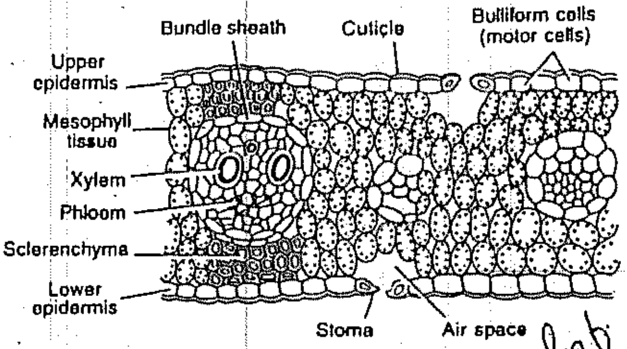


Fig. 18.23. T.S. of an isobilateral leaf

leaf leaf (leaf leaf)

(i) Epidermis

epidermis

On lower and upper side there are present generally single layered upper and lower epidermis which are cuticularized. The cells of epidermis don't possess chloroplasts.

- Stomata are present on both upper and lower epidermis (**amphistomatic**). Guard cells are the only epidermal cells, which possess chloroplast.
- In the upper epidermis, there are some large cells found in groups, which are known as **motor cells** or **bulliform** cells.

(ii) Mesophyll tissue

In between upper and lower epidermis, there is present mesophyll tissue which is **undifferentiated** into palisade and spongy parenchyma, but all the cells are alike; which are oval or spherical with intercellular spaces (just like spongy parenchyma). These cells contain chloroplast.

(iii) Vascular bundles

Large number of vascular bundles are present, some of which are small and some are big. Around each V. B. there is present **bundle sheath** of parenchymatous cells.

- Above and below larger V. B., there are present patches of sclerenchymatous cells.
- Vascular bundles are **conjoint, collateral** and closed.
- Xylem is present towards upper epidermis and phloem towards lower epidermis. Structure of xylem and phloem is as usual.

Differences between dicot and monocot leaf

	Dicot leaf	Monocot leaf
1.	**Dorsiventral.**	**Isobilateral.**
2.	**Hypostomatic**	**Amphistomatic.**
3.	Motor cells or bulliform cells are absent.	Bulliform cells are present in upper epidermis.
4.	Mesophyll is differentiated into palisade and spongy parenchyma.	Mesophyll not differentiated and all cells are like spongy parenchyma.
5.	Above and below large vascular bundles, patches of parenchymatous or collenchymatous cells are present.	**Sclerenchymatous** cells patches are present above and below the large vascular bundles.

Leaf abscission or Leaf fall

Leaf abscission is a common phenomenon in most of the woody angiosperms and gymnosperms (in some herbaceous angiosperms and pteridophytes, the leaves die on the plant without their fall or abscission).

- The falling or shedding of leaves from plant without causing any injury, is called **leaf abscission or leaf fall.**

For separation of leaf, **abscission zone is formed at the base of petiole.** This abscission zone is made of 2 layers:

(i) **Abscission layer or Separation layer :** It develops few days before the actual leaf fall and is made of few-several layers of smaller cells (formed by repeated cell division). These cells contain dense cytoplasm and starch grains. Further these cells are thin-walled and have no deposition of lignin or suberin. During separation or abscission of leaf, three types of dissolution phenomenon may occur—dissolution of middle lamellae in separation layer, dissolution of primary walls along with middle lamellae or all cells of separation layer may dissolve. This dissolution occurs in cells around vascular region and the leaf is now held only by a thin vascular strand. Now **tyloses** (tracheal plugs) develop in xylem and **callose plug formation** occurs in phloem to stop translocation of food and water. Slight disturbance causes breaking of vascular strand and leaf abscission at this stage.

(ii) **Protective layer :** After actual falling of leaf, the scar is exposed to air, which develops a **primary protective layer** by deposition of **lignin** and **suberin** on their walls as well as in intercellular spaces, which protects the exposed area from infection and dessication. In some woody trees, the primary protective layer is replaced by secondary protective layer (below primary protective layer, formed by activity of cork cambium).

SECONDARY GROWTH

In pteridophytes and monocotyledons of angiosperms, the primary plant body is complete in itself and doesn't produce any secondary tissue, whereas in **dicotyledons** of angiosperms and gymnosperms, the primary plant body forms the fundamental structure and increase in girth or diameter takes place by formation of secondary tissue. **This formation of secondary tissue is called secondary growth.**

"Secondary growth is increase in girth or diameter of axis (root and stem) of the plant by formation of secondary tissue by activity of **lateral meristem (vascular cambium and cork cambium).**"

The secondary tissue is of two types :

1. **Secondary tissue formed by true cambium** or **vascular cambium or intrastelar cambium.**
e.g., secondary xylem and secondary phloem.

2. **Secondary tissue formed by cork cambium** or **phellogen or extrastelar cambium.**
e.g., phellem or cork cells and phelloderm (sec. cortex).

Secondary growth in dicot stem

The vascular bundles in dicot stem are **conjoint, collateral** and open and are arranged in a ring.

The cambium present between xylem and phloem in vascular bundles is called **fascicular or intrafascicular** cambium (*fascicle* – bundle). Besides this, some cells of medullary rays (*i.e.*, between vascular bundles) also become meristematic and this is called **interfascicular cambium.** Both these cambia collectively constitute a complete ring of **vascular cambium or intrastelar cambium.**

This ring of vascular cambium or true cambium cuts off cells both on **outer side** and **inner side.** The cells cut off on outer side are **secondary phloem** and on inner side are **secondary xylem.** (Fig. 18.24)

abscission

- Amount of secondary xylem cut off is more than secondary phloem and thus with the formation of secondary tissue, increase in girth or diameter occurs, which is thus called **secondary growth.**
- Cambium cells are rectangular, thin-walled, full of protoplasm and having meristematic activity.

Further cambium cells are of 2 types:

(a) **Fusiform initials :** These are vertically elongated cells, which give rise to vertical elements, *e.g.*, vessels, tracheids, etc.

(b) **Ray initials :** These are horizontal in position, smaller and give rise to rays in secondry tissue.

- The structure of **secondary xylem** and **secondary phloem** is similar to that of primary xylem and primary phloem. With the increase in secondary tissue, the primary xylem and primary phloem get crushed.

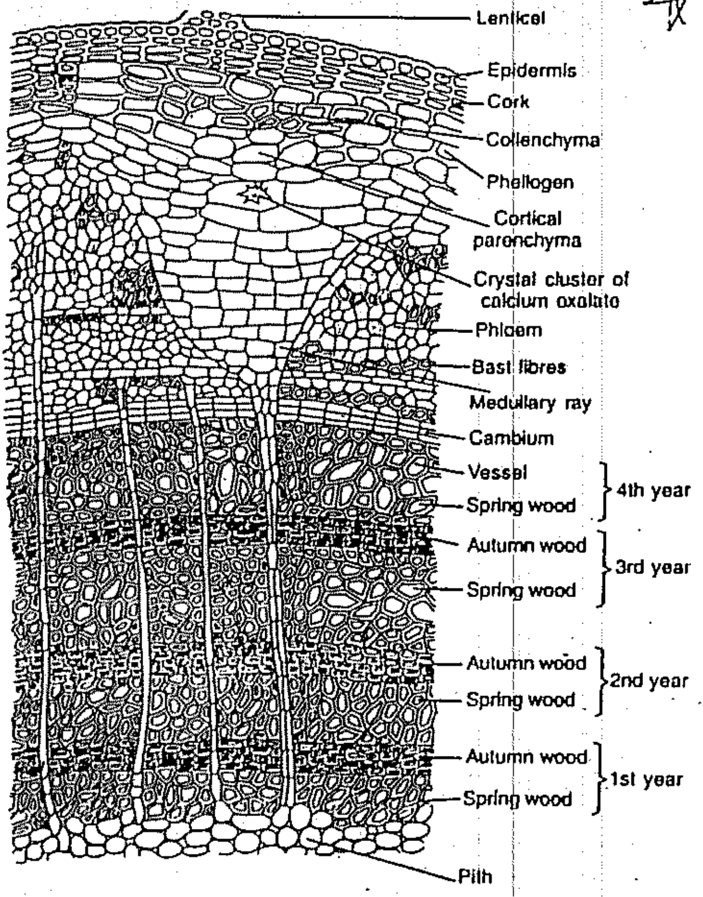

Lenticel
Epidermis
Cork
Collenchyma
Phellogen
Cortical parenchyma
Crystal cluster of calcium oxalate
Phloem
Bast fibres
Medullary ray
Cambium
Vessel
Spring wood
4th year
Autumn wood
3rd year
Spring wood
Autumn wood
2nd year
Spring wood
Autumn wood
1st year
Spring wood
Pith

Fig. 18.24. T.S. of a dicot stem with secondary growth (a portion, magnified)

Annual rings

There is a marked difference in activity of cambium with change in season. In **spring,** the activity of cambium **is more** and hence the wood elements are larger in size with wide lumen. Moreover, the amount is more and the secondary xylem or wood formed during spring is called **spring wood.** The activity of cambium is less during **winter** or **autumn** and the wood elements are smaller in size with narrow lumen. Moreover, it is lesser in amount and the wood formed during winter or autumn is called **winter** or **autumn wood.**

- **Spring wood + Autumn wood** of a year **constitute Annual ring.**
- Annual rings are **conspicuous in temperate (cold) regions.**
- The age of tree can be determined by counting annual rings in **oldest** or **basal portion** of tree trunk. **Calculation of age of the tree by counting annual rings is called Dendrochronology.**

Heart wood and sap wood

In perennial woody trees, the **central portion** of stem is darker in colour. Further it is hard and tough due to deposition of **resins, tannins, gums** and **formation of** tyloses. This central hard, tough and darker region constitutes **heart wood** or **duramen.**

The conduction function of heart wood stops due to formation of tyloses in vessels and hence heart wood is **mechanical in function.**

The outer or peripheral portion of the trunk is lighter in colour and soft which performs the function of conduction of water and minerals and it is known as **sap wood** or **alburnum.**

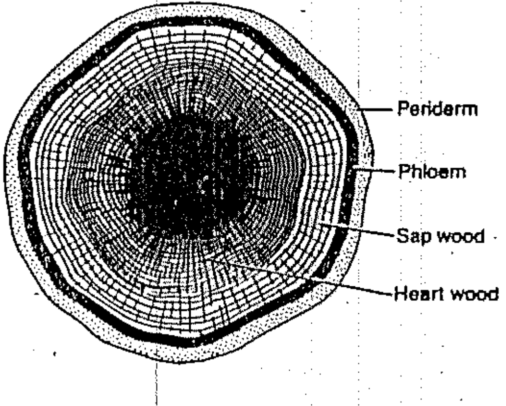

Periderm
Phloem
Sap wood
Heart wood

Fig. 18.25. Heart wood and sap wood in a T.S. of old dicot stem

Tyloses

These are balloon-like structures which are produced due to ingrowth of adjacent xylem parenchyma cells into the lumen of xylem vessels **through pits.**

- (Tylosis always passes through pit).
- (Balloon like structures which do not pass through pits are called **tylosoides,** *e.g.,* In resin canal).

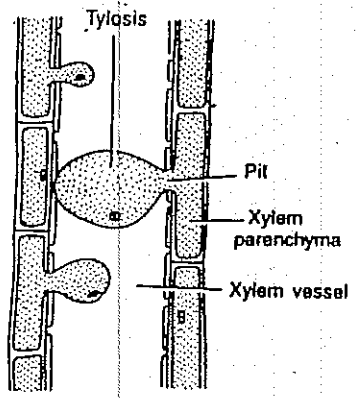

Tylosis
Pit
Xylem parenchyma
Xylem vessel

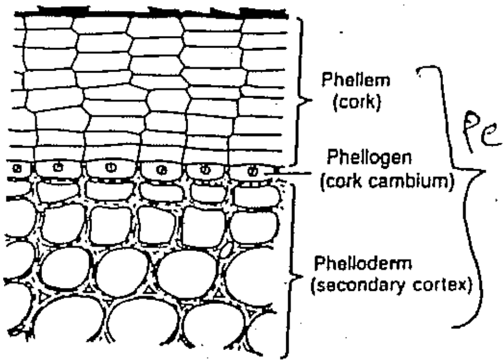
Fig. 18.26. Tyloses in a xylem vessel

Secondary tissue formed by extra stelar cambium or cork cambium or phellogen

In hypodermis or outer cortical cells, a layer becomes meristematic which is known as **cork cambium** or **phellogen**.

This phellogen also cuts off cells both on its outer side and inner side. The cells cut off on outer side are **phellem** or **cork cells** and cells cut off on inner side are **phelloderm** or **secondary cortex**.

- The phellem or cork cells are dead and have deposition of a fatty substance called **suberin** (*i.e.*, cork cells are suberized). Suberin is impervious to water and thus cork cells are **buoyant** (*i.e.*, float on water).
- **Phellem, phellogen and phelloderm** collectively constitute **periderm.**



Periderm

Fig. 18.27. Structure of periderm (showing 3 layers)

- The function of periderm is **protective** (because at maturity epidermis ruptures and hence protection function is performed by periderm).

Bark

Bark is a loose term and is used to define all the tissues, **outside vascular cambium.**

∴ Bark = Periderm + Cortex + Pericycle + Primary and secondary phloem

Rhytidome

The layer of cork cambium or phellogen becomes inactive after sometimes and successive phellogen layers develop in deeper tissues and **all the dead cells outside the innermost layer of cork cambium or phellogen constitute rhytidome.**

Lenticels

These are some **loosely arranged areas in the periderm.** Due to more activity of certain portions of phellogen, the phellem cells are cut off very rapidly and hence these cells are loosely arranged with much intercellular spaces. These loosely arranged cells are called **complementary cells** and loosely arranged areas in the periderm, are called **lenticels.**

- Lenticels are characteristics of woody stem. Lenticels help in:
  (i) Gaseous exchange.
  (ii) Transpiration (*i.e.*, lenticular transpiration).

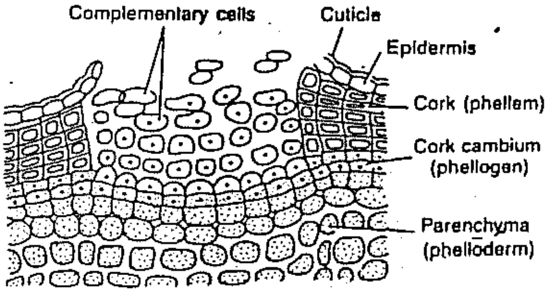


Fig. 18.28. Lenticel in cross section

Secondary growth in dicot root

The vascular bundles in dicot root are **radial** and **2 to 6** strands of xylem and phloem are present in a ring (Diarch to hexarch condition).

- During secondary growth, the parenchymatous cells **below the phloem patches and later on outside the protoxylem groups, become meristematic** and cambium like, due to which a complete ring of cambium is formed, which cuts off **secondary tissues** (secondary xylem and secondry phloem) and hence increase in girth or diameter of root occurs.

Cork cambium activity in roots

Just as in stem, **cork cambium** or **phellogen** layer is differentiated in **pericycle or cortex,** which cuts off few phellem cells on outer side and phelloderm on inner side and thus protective layer is formed.

(*i.e.*, secondary growth by extra stelar cambium).

Some abnormal features

(i) In some dicot stems, scattered vascular bundles are present (instead of in a ring).

e.g., in *Pepromea, Piper, Thallictrum, Anemone, Nymphaea*, etc.

(ii) **Anamolous or abnormal secondary growth** in some **monocot stems,** *e.g.*, in *Yucca, Dracaena, Aloe, Sensiviera* and *Agave*, etc.

Phellogen

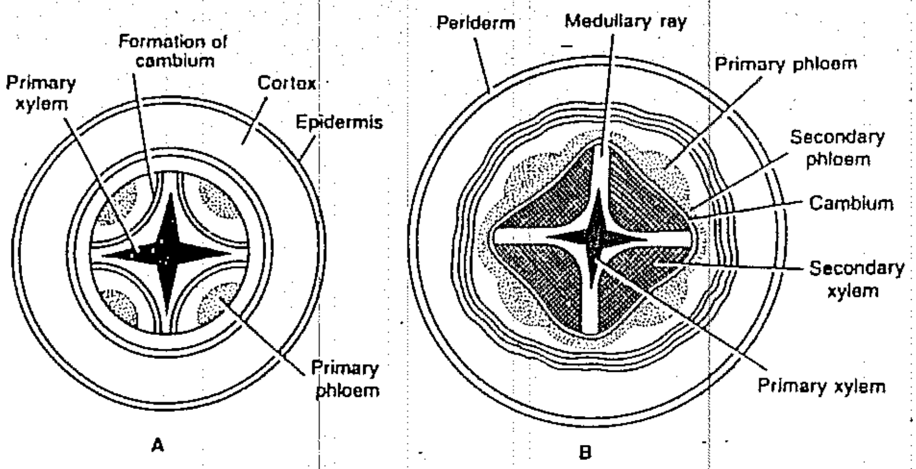

Formation of cambium
Primary xylem
Cortex
Epidermis
Primary phloem
A
Periderm
Medullary ray
Primary phloem
Secondary phloem
Cambium
Secondary xylem
Primary xylem
B

Fig. 18.29. A–B. Diagrams showing secondary growth in dicot root

Here a ring of meristematic cells is formed in the region outside the scattered vascular bundles, which cuts off parenchyma cells outside and cells in which vascular bundles differentiate, on inner side.

MULTIPLE CHOICE QUESTIONS

1. A worker who is studying the gross internal structure of plant organs after cutting sections, is working in the field of:
(a) Morphology [✓ (b) Anatomy]
(c) Histology (d) None of these

2. Who is called father of plant anatomy?
(a) Malpighi [✓ (b) N. Grew]
(c) Nageli (d) Hanstein

3. The term 'Meristem' was given by: (Pondicherry 1997)
[✓ (a) Nageli] (b) Hanstein
(c) Grew (d) M. Malpighi

4. Apical meristems are:
[✓ (a) Primary meristem] (b) Secondary meristem
(c) Promeristem (d) None of these

5. Interfascicular cambium in stem is:
(a) Primary meristem [✓ (b) Secondary meristem]
(c) Promeristem (d) All of these

6. Which is not characteristic of meristematic cells?
(a) Oval or rounded or polygonal or rectangular and isodiametric
[✓ (b) With thick cellulose walls]
(c) Without intercellular spaces
(d) With comparatively large and prominent nuclei

7. Intercalary meristem is responsible for increase in:
[✓ (a) Length] (b) Breadth
(c) Girth or diameter (d) All of these

8. Intercalary meristem at the base of internodes is found in:
[✓ (a) Grasses] (b) *Mentha*
(c) *Pinus* (d) None of these

9. Phellogen is:
(a) Apical meristem (b) Intercalary meristem
[✓ (c) Lateral meristem] (d) None of these

10. Plastochron is:
(a) A type of pigment
(b) A small organelle
(c) Instrument for cutting section
[✓ (d) Time gap between 2 successive primordia]

11. Histogen concept for shoot apex organization was put forward by:
(a) Nageli [✓ (b) Hanstein]
(c) Schmidt (d) Grew

12. Tunica-corpus concept of shoot apex organization was given by: (MPPMT 2001; Raj. PMT 2001)
[✓ (a) Schmidt] (b) Hanstein
(c) Buvat (d) Nageli

13. The divisions in 'Tunica' are:
(a) Only periclinal [✓ (b) Only anticlinal]
(c) Both (a) and (b) (d) None of these

14. 'Meristeme de attente' concept was put forward by:
(a) Clowes [✓ (b) Buvat]
(c) Nageli (d) Hanstein

15. The waiting meristem in shoot apex does not include:
(a) Meristeme sporogene
(b) Meristeme receptacularie
[✓ (c) Rib meristem]
(d) None of the above

16. Histogen 'Periblem' gives rise to: (MPPMT 2001)
(a) Vascular tissue and pith
(b) Epidermis
[✓ (c) Cortex including endodermis]
(d) None of the above

17. 'Korper-kappe concept' of root-apex organization was given by:
(a) Clowes [✓ (b) Schuepp]
(c) Hanstein (d) Nageli

18. Thickening of cell wall without lignification and specialization for mechanical functions are characteristics of:
(a) Parenchyma [✓ (b) Collenchyma]
(c) Sclerenchyma (d) Stone cells

19. A simple mechanical tissue devoid of lignin is:
(a) Parenchyma [✓ (b) Collenchyma]
(c) Sclerenchyma (d) Chlorenchyma

*20. In which organ, growth is sub-apical?
[✓ (a) Root] (b) Shoot
(c) Petiole (d) Pedicel

21. Which is a complex permanent tissue?
(a) Parenchyma (b) Collenchyma
[✓ (c) Xylem] (d) Sclerenchyma

22. Parenchyma cells having chloroplasts constitute: (St. Jones 2002)
(a) Chlorophyllous parenchyma
(b) Collenchyma
[✓ (c) Chlorenchyma]
(d) Aerenchyma

23. The chief function of collenchyma is:
(a) Storage [✓ (b) Mechanical]
(c) Assimilation (d) None of these

24. Lignified, extremely thick-walled cells, which are usually not much longer than they are broad are:
(a) Sclerenchymatous fibres
[✓ (b) Sclereids]
(c) Bast
(d) Collenchyma

25. Hardness of seed coats is due to presence of:
(a) Sclerenchymatous fibres
[✓ (b) Stone cells]
(c) Collenchyma
(d) Bast

26. Collection of different types of cells that helps in performance of a common function is:
(a) Tissue (b) Simple tissue
[✓ (c) Complex tissue] (d) None of these

27. Which of the following families lacks vessels?
(a) Winteraceae (b) Tetracentraceae
(c) Trochodendraceae [✓ (d) All of these]

28. Callose is found in:
(a) Tracheids (b) Sclerenchyma
[✓ (c) Old sieve tubes] (d) Companion cells

*29. Proteolytic enzyme secreting glands are present in which plant?
(a) *Citrus* (b) *Eucalyptus*
[✓ (c) *Drosera*] (d) *Urtica*

30. Oil glands in *Eucalyptus* are:
[✓ (a) Lysigenous] (b) Schizogenous
(c) Schizolysigenous (d) None of these

31. Bulliform cells or bubble like cells are present in:
(a) *Poa* (b) *Ammophilla*
[✓ (c) Both (a) and (b)] (d) None of these

32. In dicotyledonous leaves, stomata are:
(a) Arranged in straight rows
[✓ (b) Scattered]
(c) Absent
(d) None of the above

33. Stoma surrounded by a pair of subsidiary cells, which are at right angles to guard cells, is called:
(a) Paracytic [✓ (b) Diacytic]
(c) Anisocytic (d) Anomocytic

34. Sclerenchymatous hypodermis is present in:
(a) Dicot stem [✓ (b) Monocot stem]
(c) Both (a) and (b) (d) None of these

35. Which is commonly known as 'Starch Sheath'?
(a) Pericycle [✓ (b) Endodermis]
(c) Epidermis (d) Hypodermis

36. Casparian bands (strips) are characteristic feature of:
(CBSE 1999; Uttaranchal PMT 2001; BCECE 2002)
(a) Epidermis (b) Epiblema
(c) Exodermis [✓ (d) Endodermis]

37. Distinct endodermis is constant feature of:
[✓ (a) Roots] (b) Stem
(c) Leaves (d) All of these

38. In angiosperms, lateral roots arise from:
(CPMT 2000; CET Karnataka 2000; Raj. PMT 2001; Orissa JEE 2003)
(a) Epiblema (b) Endodermis
[✓ (c) Pericycle] (d) None of these

39. Sclerenchymatous and many layered pericycle is found in:
(a) Cicer root (b) Maize root
[✓ (c) Smilax root] (d) None of these

40. Heterogenous pericycle is found in:
(a) *Cucurbita* stem [✓ (b) Sunflower stem]
(c) Cicer stem (d) All of these

41. Passage cells are features of:
(a) Epidermis [✓ (b) Endodermis]
(c) Pericycle (d) None of these

*42. Centrifugal xylem is feature of:
(a) Root (b) Stem
(c) Both (a) and (b) (d) None of these

bcdefgh

aaBH

102

43. Roots possess .... vascular bundles.
[✓ (a) Radial] (b) Conjoint
(c) Collateral (d) Bicollateral

44. Bicollateral vascular bundles are in: **(BHU 2001)**
[✓ (a) Cucurbitaceae] (b) Solanaceae
(c) Myrtaceae [✓ (d) All of these]

45. Leptocentric vascular bundles are in:
(a) Ferns (b) *Yucca*
(c) *Dracaena* [✓ (d) Both (b) and (c)]

46. Velamen is characteristic of: **(CPMT 2001)**
(a) All roots (b) All stems
[✓ (c) Aerial roots of orchids] (d) Prop roots

47. In a dicot root:
(a) Monarch condition
[✓ (b) Diarch to hexarch condition]
(c) Polyarch condition
(d) None of the above

48. Conjunctive tissue is present:
[✓ (a) Between xylem and phloem strands]
(b) Between metaxylem and protoxylem
(c) In cortex
(d) In pith

49. Heteroarchy in roots is found in:
(a) Sunflower (b) Maize
[✓ (c) Nymphaea] (d) Nelumbo

50. Which is not character of stem?
(a) Conjoint, collateral vascular bundles
(b) Endarch condition
(c) Usually chlorenchyma present
[✓ (d) Hair are unicellular]

51. Scattered vascular bundles are present in:
(a) Dicot root [✓ (b) Monocot stem]
(c) Dicot stem (d) None of these

52. Bundle sheath is present around vascular bundles in:
[✓ (a) Monocot stem] (b) Dicot stem
(c) Both (a) and (b) (d) None of these

53. Schizolysigenous cavity is present in:
[✓ (a) Maize stem] (b) Sunflower root
(c) Nymphaea root (d) None of these

54. Dorsiventral leaves are present in:
[✓ (a) Dicots] (b) Monocots
(c) Both (a) and (b) (d) None of these

55. Mesophyll is undifferentiated into palisade and spongy parenchyma in:
(a) Dorsiventral leaf [✓ (b) Isobilateral leaf]
(c) Both (a) and (b) (d) None of these

56. Isobilateral leaves are:
(a) Hypostomatic (b) Epistomatic
[✓ (c) Amphistomatic] (d) None of these

57. Vascular cambium cuts:
(a) Secondary xylem on inner side
(b) Secondary phloem on outer side
(c) Both secondary xylem and secondary phloem on both sides
(d) Secondary xylem on inner side and secondary phloem on outer side

Pocy

58. No secondary growth appears in monocot stems, because:
(a) Vascular bundles are scattered
[✓ (b) Vascular bundles closed]
(c) Vascular bundles enclosed by sclerenchyma
(d) None of the above

59. The only plant cells without nuclei among following are: **(CPMT 1998)**
(a) Cambium cells [✓ (b) Xylem vessels]
(c) Root hairs (d) Companion cells

60. Growth rings in stem are formed due to activity of:
(a) Fascicular cambium (b) Interfascicular cambium
[✓ (c) Both (a) and (b)] (d) Secondary xylem

61. The cross section of a trunk of tree shows 50 annual rings, the age of tree is:
(a) 25 years (b) 50 years
(c) 100 years (d) 50 months

***62.** Growth rings or annual rings are well marked in tree growing in: **(Raj. PMT 1990)**
(a) Shimla (b) Mumbai/Delhi
(c) Chennai (d) Kolkata/Udaipur

***63.** Grafting is not possible in monocots, because of: **(Raj. PMT 2001)**
(a) Lack cambium (b) Scattered vascular bundles
(c) Parallel veins (d) Herbaceous

64. Dendrochronology is the study of: **(Kerala PMT 2003)**
(a) Height of tree
(b) Diameter of tree
(c) Age of tree by counting annual rings
(d) None of the above

65. Alburnum is:
(a) Heart wood (b) Sap wood
(c) Hard wood (d) Soft wood

66. Function of duramen is:
(a) Conduction (b) Mechanical
(c) Both (a) and (b) (d) None of these

67. Balloon like structures formed by adjacent parenchyma cells into xylem vessels through pits are:
(a) Tyloses (b) Callose
(c) Tylosoides (d) None of these

68. Some roots show wrinklings on root surface at maturity, are called:
(a) Shrinken roots (b) Crinkled roots
(c) Contractile roots (d) Heteroarchic roots

69. Cork cambium in stem is formed by:
(a) Epidermis [✓ (b) Hypodermis or cortex]
(c) Pericycle (d) Endodermis

70. Periderm is made of: **(CPMT 2002)**
(a) Cork and secondary cortex
(b) Cork cambium, cork and secondary phloem
(c) Cork cambium, cork and secondary cortex
(d) Cork alone

71. Phellem is made of:
(a) Dead cells (b) Photosynthetic cells
(c) Meristematic cells (d) All of these

72. Cork cells are airtight due to deposition of:
(a) Cutin (b) Suberin
(c) Lignin (d) All of these

73. Protoxylem in dorsiventral leaf is directed towards:
(a) Upper epidermis (b) Lower epidermis
(c) Centre (d) Any where

74. Bark of a tree comprises:
(a) All tissues outside vascular cambium
(b) All tissues outside cork cambium
(c) Cork, secondary cortex
(d) Only cork

75. The loosely arranged areas in periderm are:
(a) Hydathodes (b) Cyphallae
(c) Lenticels (d) Rhytidome

***76.** Complementary cells are associated with:
(a) Lenticels (b) Hydathodes
(c) Rhytidome (d) Bark

77. Function of Lenticels is: **(CBSE 2002)**
(a) Gaseous exchange (b) Transpiration
(c) Both (a) and (b) (d) None of these

78. Lenticels are characteristic of:
(a) Herbaceous stem (b) Woody stems
(c) All stems (d) Large roots

79. In dicot root, cambium pathes arise :
(a) Below xylem and above phloem
(b) Below phloem and above protoxylem groups
(c) Only below phloem
(d) Only above protoxylem groups

80. If the sign was nailed to the side of a tree 5′ above the ground in 2000, how would the sign be in 2004, if the tree grows 4″ taller each year: **(Raj. PMT 2001)**
(a) 5′ (b) 6′4″
(c) 5′ 4″ (d) None of these

81. A monocot stem with secondary growth is:
(a) *Lilium* (b) *Cocos*
(c) *Asparagus* (d) *Yucca*

82. The tip of root apical meristem is capped by histogen called:
(a) Dermatogen (b) Calyptrogen
(c) Periblem (d) Plerome

83. The actual age can be determined by counting the annual rings in:
(a) Oldest portion (b) Middle portion
(c) Youngest portion (d) Any portion

84. Conducting part of phloem is also named as: **(CET J & K 2002)**
(a) Hadrome (b) Leptome
(c) Bast (d) None of these

85. Longest vessel is of:
(a) *Sequoia* (b) *Eucalyptus*
(c) *Populus* (d) Oak

***86.** Which is more mature?
(a) Protoxylem (b) Metaxylem
(c) Both of same age (d) None of these

87. Autumn wood can be distinguished from spring wood by:
(a) Broad vessels and tracheids
(b) Narrow vessels and tracheids

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زوالوجی ڈیپارٹمنٹ، لیب بلڈنگ، اسٹیشنری

(c) Red colour
(d) By cambium

88. The conducting part of xylem is called:
(a) Leptome (b) Hadrome
(c) Bast (d) None of these

89. The complex tissues include: (MPPMT 1993]
(a) Sclereids (b) Sclerenchyma
(c) Secretory tissue (d) Collenchyma

90. Secondary growth (or) increase in diameter is due to: (Raj. PMT 1990)
(a) Ground meristem (b) Procambium
(c) Cork and phelloderm (d) Vascular cambium

91. Periblem gives rise to:
(a) Pericycle (b) Cortex
(c) Medulla (d) Epidermis

92. Quiescent centre is present in: (CPMT 2002)
(a) Root apex (b) Shoot apex
(c) Vegetative apex (d) Reproductive apex

93. Collenchyma is present in: (CBSE 1990)
(a) Herbaceous monocots
(b) Herbaceous dicots
(c) All herbaceous plants
(d) Pteridophytes and monocots

94. Presence of lignin in cell wall is a characteristic feature of:
(a) Woody tissue (b) Parenchyma
(c) Phloem (d) Cork

95. Xylem fibre is: (Raj. PMT 1990)
(a) Bast fibre (b) Wood fibre
(c) Heart wood (d) Libriform fibre

96. Companion cells are seen associated with:
(a) Sieve tubes (b) Collenchyma
(c) Medullary parenchyma (d) Secondary cambium

97. Resin canals are:
(a) Schizogenous (b) Lysigenous
(c) Schizolysigenous (d) None of these

98. Sieve tubes and companion cells are found in:
(a) Xylem (b) Phloem
(c) Meristems (d) Cortex

99. The origin of a vegetative branch is: (Raj. PMT 1992)
(a) Endogenous
(b) Exogenous
(c) Schizogenous
(d) Internal from intercalary meristem

*100. Cortex and pith are not distinguished in: (Raj. PMT 1990)
(a) Monocot stem (b) Monocot root
(c) Dicot stem (d) Dicot root

101. The basic difference between stem and root is that stem is:
(a) Endarch (b) Exarch
(c) Mesarch (d) Polyarch

102. Dicot isobilateral shaded leaves are called:
(a) Mesophytic (b) Sciophytic
(c) Heliophytic (d) Xerophytic

103. Metaxylem in a dorsiventral leaf is directed towards:
(a) Upper epidermis (b) Lower epidermis
(c) Centre (d) Any where

104. Girdling experiment conveys no sense in sugar cane because: (CBSE 1992)
(a) Vascular bundles are collateral
(b) Vascular bundles are scattered
(c) Vascular bundles are closed
(d) Cortex and pith not demarcated

105. Wood is common name for:
(a) Vascular bundles
(b) Secondary xylem
(c) All tissues which form a plant body
(d) Phloem

106. Age of a plant can be calculated by: (CPMT 1993)
(a) Measuring its height
(b) Counting lateral branches
(c) Counting annual rings
(d) All of the above

107. Sapwood is synonymous with:
(a) Outer part of secondary xylem
(b) Inner part of secondary xylem
(c) Periderm
(d) Bark

108. Most of our trees grow faster in:
(a) Autumn (b) Winter
(c) Summer (d) Spring

109. Which structure is not present in the leaf of a dicot and stem of a monocot?
(a) Phloem (b) Stomata
(c) Guard cells (d) Lenticels

110. After two years of secondary growth, cortex of a dicot root and stem is:
(a) Unaffected completely (b) Sloughed off
(c) Largely lost (d) Converted into cork

111. Monocot leaves are characterised by: (CBSE 1990)
(a) Lack of differentiation between palisade and spongy tissue
(b) Permanently opened stomata
(c) Bulliform cells absent
(d) Phloem on the abaxial side

112. Cambium causes growth in:
(a) Girth (b) Periphery
(c) Leaves (d) Length

113. Sclerenchymatous bundle sheath is present in:
(a) Grass (b) Sunflower
(c) Banyan (d) Gram

114. Collateral bundles occur in:
(a) Dicot stem only
(b) Monocot stem only
(c) Dicot as well as monocot stems
(d) Leaves only

115. Which of the following plant cells lack nuclei?
(a) Cambial cells (b) Root hairs
(c) Sieve cells (d) Xylem parenchyma

116. Collenchyma differs from sclerenchyma in:
(a) Retaining protoplasm at maturity
(b) Having thick walls

(c) Having a wide lumen
(d) Being meristematic

117. Root cap regenerates from:
(a) Calyptrogen (b) Plerome
(c) Periblem and histone (d) Dermatogen

118. Who coined the term tissue?
(a) Hooke (b) Grew
(c) Nageli (d) Leeuwenhoek

119. Maximum growth in root occurs:
(a) At its tip (b) Towards light
(c) Behind the apex (d) Towards darkness

120. Monocot leaves grow by: **(CBSE 1990)**
(a) Apical meristem (b) Lateral meristem
(c) Intercalary meristem (d) Dermatogen

121. The living mechanical tissue of a dicot plant is:
(a) Parenchyma (b) Collenchyma
(c) Sclerenchyma (d) Chlorenchyma

122. All the xylem elements, when mature, are dead except:
(a) Tracheids (b) Vessels
(c) Xylem parenchyma (d) Xylem fibres

123. Sieve tubes are a part of: **(Raj. PMT 1991)**
(a) Protoxylem (b) Metaxylem
(c) Vascular cambium (d) Bast

124. Food is transported by: **(Raj. PMT 1990)**
(a) Xylem (b) Phloem
(c) Cortex (d) Pith

125. Velamen cells are present:
(a) Within the epidermis (b) Outside the exodermis
(c) Outside the cortex (d) Below the endodermis

126. In general, the cells of cortex lack:
(a) Chlorophyll (b) Nucleus
(c) Reserve food (d) Nucleolus

127. When xylem has phloem on two sides, the vascular bundle is known as:
(a) Endarch (b) Exarch
(c) Bicollateral (d) Collateral

128. Bordered pits are found in:
(a) Phloem (b) Protoxylem
(c) Metaxylem (d) Sclerenchyma

129. Pith is not well developed in:
(a) Monocot stem (b) Monocot root
(c) Dicot stem (d) Dicot root

130. Bordered pits occur in: **(CBSE 1993)**
(a) Sieve tube members (b) Sieve cells
(c) Vessels members (d) Companion cells

131. Metabolic energy is most extensively used in:
(a) Phloem (b) Cork
(c) Cambium (d) Tracheids

132. The cork of dicots is a derivative of:
(a) Phellogen (b) Vascular cambium
(c) Phloem (d) Xylem

133. The outer bark of a tree comprises of:
(a) Cork (b) Rhytidome
(c) Both together (d) Cork and secondary cortex

134. Lenticels do not occur on: **(Raj. PMT 1992)**
(a) Stem (b) Root
(c) Leaf (d) Fruit

135. Compact wood with little parenchyma is termed: **(Raj. PMT 1991)**
(a) Heart wood (b) Hard wood
(c) Pycnoxylic wood (d) Manoxylic wood

136. Which of the following is living? **(CPMT 1993)**
(a) Vessels (b) Sieve tubes
(c) Companion cells (d) Phloem fibres

137. Branch of Botany dealing with the internal organization of plants is:
(a) Physiology (b) Ecology
(c) Anatomy (d) Cytology

138. The histogen present at the apex of the root tip is: **(AFMC 1993)**
(a) Dermatogen (b) Procambium
(c) Calyptrogen (d) Pleurome

139. Aerenchyma is found in:
(a) Lithophytes (b) Hydrophytes
(c) Sciophytes (d) Xerophytes

140. Periclinal division in a cell takes place by: **(AMU 1992)**
(a) Vertical cleavage (b) Transverse cleavage
(c) Perpendicular cleavage (d) Tangential cleavage

141. Aerenchyma is helpful to plants by: **(CPMT 1992)**
(a) Providing buoyancy in hydrophytes
(b) Promoting photosynthesis
(c) Giving mechanical strength to plants
(d) Giving flexibility to plants

142. Mechanical tissue consisting of living cells is:
(a) Sclerenchyma (b) Collenchyma
(c) Chlorenchyma (d) Parenchyma

143. The tissue responsible for translocation of food material is: **(CPMT 1992)**
(a) Parenchyma (b) Sieve tubes
(c) Vessels (d) Fibres

144. Bast fibres are frequently found in:
(a) Secondary xylem (b) Secondary phloem
(c) Primary phloem (d) Primary xylem

145. Excretion of water occurs through:
(a) Lenticel (b) Stomata
(c) Hydathode (d) Leaf scars.

146. Vascular bundles are derived from:
(a) Dermatogen (b) Procambial strands
(c) Periderm (d) Periblem or Cortex

147. Radial exarch condition occurs in:
(a) Leaf (b) Root
(c) Maize stem (d) Fern stem and Petiole

148. Phloem parenchyma is absent in:
(a) Dicot stem (b) Dicot leaf
(c) Monocot stem (d) Dicot root

149. Mesophyll is well differentiated in:
(a) Dicot leaves
(b) Submerged hydrophytes

(c) Monocot leaves
(d) Halophytic stems

150. Vascular cambium gives rise to:
(a) Xylem and Phloem
(b) Xylem, phloem and vascular rays
(c) Xylem and medullary rays
(d) Phloem and bark

151. The oldest layer of secondary phloem is:
(a) Outside vascular cambium
(b) Inside vascular cambium
(c) Inside primary phloem
(d) Outside secondary xylem

152. In dicot root, the cork cambium develops from or originates in:
(a) Conjunctive tissue (b) Epidermis or endodermis
(c) Pericycle (d) Cortex

153. Term bark signifies all the tissues outside:
(a) Cork (b) Phellogen
(c) Vascular cambium (d) Cortex

154. Sap wood is:
(a) Inner part of secondary phloem
(b) Outer part of secondary phloem
(c) Both (a) and (b)
(d) None of the above

155. Bordered pits are common in: **(CPMT 1993)**
(a) Monocots (b) Dicots
(c) Gymnosperms (d) All of these

156. Meristems are found in:
(a) *Cycas* stem (b) Fern leaf
(c) Pollens of *Pinus* (d) Fern rhizome

***157.** Meristematic cells contain more of: **(EAMCET 1991)**
(a) Fats (b) Protein
(c) Sugar (d) Salts

158. Histogen theory believes that epidermis is derived from the:
(a) Cortex (b) Periblem
(c) Dermatogen (d) Cambium

159. Collenchyma is found in: **(CBSE 1990)**
(a) Herbaceous climbers (b) Hydrophytes
(c) Woody climbers (d) Xerophytes

160. Safranin stains which element of a tissue?
(a) Starch (b) Lignin
(c) Protein (d) Cutin

161. Bordered pits are very common among tracheids of:
(a) Monocotyledons (b) Dicotyledons
(c) Pteridophytes (d) Gymnosperms

162. Bast fibres in woody stem belong to: **(CPMT 1991)**
(a) Cork (b) Phloem
(c) Cortex (d) Xylem

***163.** Epithem tissue is associated with: **(BCECE 2002)**
(a) Transpiration (b) Photosynthesis
(c) Guttation (d) Exudation

164. When phloem surrounds xylem, the vascular bundle is:
(a) Concentric leptocentric (b) Concentric hadrocentric
(c) Conjoint bicollateral (d) Conjoint collateral

165. Xylem in root is: **(CBSE 1990)**
(a) Endarch (b) Exarch
(c) Mesarch (d) Different in different roots

166. The lacunae in the vascular bundles of monocot stem is:
(a) Metaxylem (b) A mucilage canal
(c) Lysigenous cavity (d) A large sized vessel

167. The vascular bundles in *Lagenaria* and *Cucurbita* stem are:
(a) Radial (b) Collateral
(c) Bicollateral (d) Concentric

168. A leaf scar protects the plant from:
(a) Air and Water (b) Heat
(c) Transpiration (d) Evaporation

169. Fusiform initials form:
(a) Tracheary elements (b) Vascular rays
(c) Phloem parenchyma (d) Ray parenchyma

170. Leaves fall from branches on account of:
(a) Completion of their life
(b) Formation of abscission layer
(c) Formation of calyptrogen
(d) Fall in atmospheric temperature

171. Secondary phloem is nearer to: **(Raj. PMT 1992)**
(a) Secondary xylem (b) Cambium
(c) Cortex (d) Pith

172. If a stem is girdled: **(Raj. PMT 1990)**
(a) Root dies first
(b) Shoot dies first
(c) Both die together
(d) None of the above would die

173. Intercalary meristem results in:
(a) Secondary growth (b) Primary growth
(c) Apical growth (d) Periderm formation

174. Stelar region (vascular tissue, pericycle and pith) are formed from:
(a) Periblem (b) Plerome
(c) Dermatogen (d) Tunica

175. Root cap is not found in: **(Raj. PMT 1991)**
(a) Hollyhock (b) Pistia
(c) Sunflower (d) China rose

***176.** A parenchyma cell which stores ergastic materials or waste substances is:
(a) Phragmoblast (b) Conidioblast
(c) Idioblast (d) Blastomere

177. Fibre, belongs to the tissue:
(a) Parenchyma (b) Collenchyma
(c) Sclerenchyma (d) Aerenchyma

178. Tyloses are:
(a) Compound sieve plates
(b) Laticiferous channels
(c) Tracheal plugs which block the lumen of vessels and tracheids
(d) Specialised secretory cells

179. Hydathodes occur in:
(a) Stem (b) Leaf
(c) Root (d) Fruit

180. Dermal tissue is derived from:
(a) Periblem (b) Dermatogen
(c) Procambium (d) Plerome

181. The layer of cells lying between endodermis and vascular bundle in:
(a) Cortex (b) Pith
(c) Pericycle (d) Exodermis

182. Which of the wall of stomata is thick?
(a) Inner (b) Outer
(c) Lateral (d) Upper

183. In submerged hydrophytes, stomata are found: **(CPMT 1990)**
(a) On upper surface of leaf
(b) On lower surface of leaf
(c) On both surface of leaf
(d) Nowhere on the plant

184. Which of the following type of stomata is most common in plants?
(a) Oat type (b) Mulberry type
(c) Potato type (d) Alfalfa type

185. When a meristematic tissue cambium is present inside a vascular bundle, the bundle is said to be: **(Raj. PMT 1990)**
(a) Conjoint (b) Open
(c) Closed (d) Collateral

186. What arrangement of vascular tissue is characteristic of roots?
(a) Conjoint, endarch (b) Radial, endarch
(c) Radial, exarch (d) Conjoint, exarch

187. Conjoint, collateral and closed vascular bundles are found in: **(Raj. PMT 1992)**
(a) Monocot root (b) Monocot stem
(c) Dicot root (d) Dicot stem

188. Which of the dorsiventral leaf has a multilayered epidermis: **(CBSE 1990)**
(a) Mulberry (b) Banyan
(c) *Nerium* (d) *Eucalyptus*

189. Which of these exhibits secondary growth?
(a) Gametophytes of fern
(b) Homosporous sporophytes
(c) Gametophytes
(d) Sporophytes of spermatophytes

190. Which of the following type of cells constitute a vascular cambium?
(a) Fusiform and ray initials
(b) Xylem and phloem
(c) Parenchyma and collenchyma
(d) Cork initials

191. Another term for cork is:
(a) Phellogen (b) Phelloderm
(c) Periderm (d) Phellem

192. Cork cells are:
(a) Meristematic (b) Dead
(c) Living (d) Photosynthetic

193. Which of the tissue is present in periderm?
(a) Xylem (b) Bast
(c) Phellem (d) Duramen

194. Growth rings are formed due to activity of:
(a) Intrastelar cambium (b) Intercalary cambium
(c) Extrastelar cambium (d) Primary cambium

195. The process by which the plant becomes woody is called:
(a) Calcification (b) Lignification
(c) Impregnation (d) Fossilisation

196. Abnormal secondary growth is observed in: **(CBSE 1993)**
(a) *Dracaena* (b) Wheat
(c) Ginger (d) Rice

197. Meristematic activity is at its maximum in the:
(a) Stem apex (b) Bud
(c) Leaf (d) Root hair

198. Sclerenchymatous cells in their cell walls have large percentage of:
(a) Cellulose (b) Pectin
(c) Lignin (d) Silica

199. Which of the following plant cells are without vacuoles and without nuclei?
(a) Cambium cells (b) Xylem vessels
(c) Root hairs (d) Companion cells

200. The cell functionally associated with sieve tube is:
(a) Phloem fibres (b) Phloem parenchyma
(c) Companion cell (d) Collenchyma

201. Resin ducts are found in: **(Raj. PMT 1991)**
(a) Pines (b) Bamboos
(c) Teak (d) Sal

202. Velamen is needed for: **(BHU 1992; BCECE 2002)**
(a) Respiration of plants (b) Protection of tissues
(c) Absorption of moisture (d) None of these

203. Casparian strips of suberin occur in: **(CPMT 1997; Raj. PMT 1990)**
(a) Epidermis (b) Endodermis
(c) Pericycle (d) Phloem

204. If xylem is surrounded by phloem on all sides, the vascular bundle is called:
(a) Amphivasal (b) Leptocentric
(c) Radial (d) Amphicribal

205. A leaf which possesses stomata exclusively on its upper side is called: **(Raj. PMT 1991)**
(a) Oat type (b) Mulberry type
(c) Lotus type (d) Cactus type

206. A tissue is a group of cells which are:
(a) Similar in origin, but dissimilar in form and function
(b) Dissimilar in origin, form and function
(c) Dissimilar in origin but similar in form and function
(d) Similar in origin, form and function

207. A meristem may be defined as the group of cells which:
(a) Add to the bulk of the plant
(b) Conserve food
(c) Divide continuously to give rise to new cells
(d) Elongate and add to the group of cells

208. Where would you look for an active cell division in a plant? (OR) The meristematic activity is at maximum in:
(a) Bud (b) Leaf
(c) Apex (d) Root hair

209. What tissue makes up the embryo of a seed?
(a) Meristematic tissue (b) Permanent parenchyma
(c) Collenchyma (d) Sclerenchyma

210. Bamboo, grass and mint stem elongate by the activity of:
(a) Primary meristem
(b) Secondary meristem
(c) Intercalary meristems
(d) Apical meristems

211. If there are more than one tunica layers in a stem apex, which among the following is most likely to happen?
(a) All the layers will develop into epidermal cells
(b) Only the outer layer will develop into epidermal cells
(c) All the layers will develop into cortex
(d) Inner layer develops into cortex

212. The organization of shoot apex into tunica and carpus is determined largely on the basis of:
(a) Regions of meristematic activity
(b) Planes of cell division
(c) Rate of shoot tip growth
(d) Rate of cell division

213. A leaf scar covering the abscission layer is composed of:
(a) Pectin (b) Resin
(c) Cutin (d) Pectose and cellulose

214. In which of the following ways is parenchyma the basic or fundamental type of tissue?
(a) Morphologically (b) Physiologically
(c) Phylogenetically (d) All of these

215. Lateral meristem is responsible for: **(BHU 1991)**
(a) Growth in length (b) Growth in parenchyma
(c) Growth in thickness (d) Growth in cortex

216. Primary growth is caused by (or) the length of a plant axis increases by:
(a) Apical meristem (b) Lateral meristem
(c) Dermatogen (d) Plerome

217. Outermost layer of cells in transverse section of stem is:
(a) Epidermis (b) Cortical layer
(c) Hypodermis (d) Endodermis

218. A nail was driven into the trunk of a tree at a point 1.5 metres above the soil level. After three years, the nail will:
(a) Moves up (b) Moves down
(c) Moves sideways (d) Remains where it was

219. Histogens are components of (or) the histogens are differentiated in:
(a) Apical meristem (b) Intercalary meristem
(c) Lateral meristem (d) Secondary meristem

220. Dermatogen is a tissue formed by apical meristem and it develops into:
(a) Cortex (b) Vascular bundle
(c) Epidermis (d) Ground tissue (pith)

221. Name the tissue from which procambium and primary structures of plant originate:
(a) Phellogen (b) Promeristem
(c) Calyptrogen (d) None of these

222. Cambium is considered a lateral meristem because:
(a) It increases the height and diameter of a stem
(b) It gives rise to lateral branches
(c) It increases the girth of a plant
(d) It increases the length of a plant

223. The function of a root cap is:
(a) Protection of root tip and control of geotropic movement
(b) Storage of food products
(c) Absorption of nutrients
(d) Nothing

224. Tunica and corpus organization occurs in:
(a) Root apex (b) Shoot apex
(c) Cambium (d) Intercalary meristems

225. Thickening of cell wall, lignification and specialisation for mechanical function are characteristics of:
(a) Sclerenchyma (b) Collenchyma
(c) Chlorenchyma (d) Parenchyma

226. Tracheids, vessels, wood fibres and wood parenchyma are constituents of: **(CPMT 1992)**
(a) Phloem (b) Xylem
(c) Tyloses (d) None of these

*227. Vessels differ from tracheids:
(a) In being living
(b) In being derived from a single cell
(c) In having vertical row of cells with cross walls dissolved
(d) Because they conduct water

228. An elongated cell with tapering ends is termed:
(a) Collenchyma (b) Vessel
(c) Sclerenchyma (d) Tracheids

229. Phloem of angiosperm is different from that of pteridophytes and gymnosperms in:
(a) The absence of enzymes
(b) Presence of endocytosis
(c) Presence of companion cells
(d) None of the above

230. A mature sieve tube differs from a vessel:
(a) In lacking a functional nucleus
(b) Absence of lignified walls
(c) Being nearly dead
(d) Lacking cytoplasm

231. A nectar secreting gland cell characteristically contains: **(BHU 1990)**
(a) Granular cytoplasm filling the cell and a small nucleus
(b) Granular cytoplasm lining a central vacuole and a small nucleus
(c) Granular cytoplasm filling the cell and a large conspicuous nucleus
(d) Vacuolated cytoplasm but with a large nucleus

232. Laticiferous vessels are found in: **(CBSE 1996)**
(a) Xylem tissue (b) Phloem tissue
(c) Cortex (d) None of these

233. Epidermal outgrowths are known as:
(a) Trichomes (b) Leaves
(c) Stomata (d) Buds

234. Velamen, the spongy tissue is found in: (Raj. PMT 2002)
(a) Breathing roots of halophytes
(b) Parasitic plants
(c) All aerial roots
(d) Aerial roots of epiphytic orchids

235. A tissue with spiral thickening in the cell wall capable of absorbing water from air is known as:
(a) Cork (b) Velamen
(c) Epiblema (d) Hypodermis

236. Latex vessels are prominent in:
(a) Calotropis (b) Vinca
(c) Papaver (d) All of these

237. In orchids velamen tissue helps in:
(a) Protection of the roots
(b) Absorption of water from its host
(c) Absorption of moisture from air
(d) Perennation of roots

238. Bulliform cells (or motor cells) are present in the upper epidermis of:
(a) Aquatic plants (b) All grasses
(c) Only xerophytic leaves (d) Halophytic dicots

239. In *Nymphaea* the stomata are present on:
(a) Adaxial (upper surface) of leaf
(b) Abaxial (lower surface) of leaf
(c) On both the surfaces of leaf
(d) None of the above

240. The number of stomata per square cm of leaf is: **(CPMT 1991)**
(a) Less than one hundred (b) Less than one thousand
(c) Less than one million (d) None of these

241. Laticiferous vessels instead of laticiferous cells are found in: **(BHU 1990)**
(a) *Ficus* (b) *Calotropis*
(c) Poppy (d) *Nerium*

242. When xylem and phloem are on same radii, the vascular bundles are said to be: **(Raj. PMT 1990)**
(a) Radial (b) Conjoint/Collateral
(c) Concentric (d) Exarch/centripetal

243. A vascular bundle in which phloem is on both the sides of the xylem and separated from it by strips of cambium is said to be: **(Raj. PMT 2001)**
(a) Collateral open (b) Bicollateral open
(c) Concentric (d) Bicollateral closed

244. Origin of lateral root or secondary root is:
(a) Exogenous (b) Endogenous
(c) Lysigenous (d) Schizogenous

245. In bicollateral bundle: **(CPMT 1992)**
(a) Xylem is sandwitched between phloem
(b) Phloem is sandwitched between xylem
(c) Xylem and phloem present as two lateral strands
(d) Xylem is embedded in phloem

246. In root the pericycle gives rise to:
(a) Branch root and cork cambium
(b) Cortex and pith
(c) Xylem and phloem
(d) Epidermis and vascular bundles

247. Collenchymatous hypodermis is characteristic feature of:
(a) Dicot stem
(b) Monocot stem
(c) Monocot as well as dicot stem
(d) Hydrophytes

248. Passage cells are present in: **(CBSE 1990; CET Karnātaka 2000)**
(a) Epidermis
(b) Endodermis
(c) Xylem
(d) Lenticels and hydathodes

249. Cortex is predominantly made up of:
(a) Chlorenchyma (b) Parenchyma
(c) Collenchyma (d) Sclerenchyma

250. Endodermis is a part of: **(Raj. PMT 1992)**
(a) Cortex (b) Stele
(c) Pith (d) Pericycle

251. Pericycle of root is made up of:
(a) Parenchyma (b) Collenchyma
(c) Sclerenchyma (d) Fibres

252. Seat of the origin of lateral root or secondary root is: **(Raj. PMT 1992)**
(a) Endodermal cells against phloem
(b) Pericycle cells against protoxylem
(c) Cortical cells below root hairs
(d) Epiblema/phellogen

253. Bicollateral bundles are found in the stem of: **(Raj. PMT 1991; CPMT 1991)**
(a) *Cycas*/Sunflower (b) Gram/Canna
(c) Pumpkin (d) *Dracaena*

254. A vascular bundle in which phloem is embedded in xylem is:
(a) Collateral (b) Bicollateral
(c) Amphicribal (d) Amphivasal

255. A concentric amphivasal vascular bundle is that in which: **(CPMT 1990)**
(a) Centrally located xylem is surrounded by phloem
(b) Centrally located phloem is surrounded by xylem
(c) Phloem is flanked by xylem on interior sides only
(d) Xylem is flanked by phloem on exterior sides only

256. Amphivasal vascular bundles are found in:
(a) *Cycas* and *Dryopteris*
(b) *Dracaena* and *Yucca*
(c) *Helianthus* and *Cucurbita*
(d) Maize and wheat

257. The character of monocots is: **(CPMT 1991)**
(a) Net veined leaves
(b) Annual rings
(c) Seeds with two masses of stored food
(d) Conducting strand scattered throughout ground tissue

258. Which of the following is not true difference between a stem and a root?
(a) The largest xylem vessel lies towards outside in stem and inside in root
(b) The xylem and phloem tissues are arranged on the same radii in stem while they alternate in root
(c) Pith is widest tissue in dicot root and cortex is widest in dicot stem
(d) None of the above

259. Mesophyll is well differentiated in:
(a) Dicot leaves (b) Monocot leaves
(c) Submerged hydrophytes (d) Halophytic stems

260. Which side of a bifacial (dorsiventral) leaf possesses more stomata?
(a) Adaxial side
(b) Abaxial side
(c) Present on tip and margins only
(d) None of the above

261. In which of the following, the phloem occurs in two patches?
(a) Maize (b) *Cucurbita*
(c) Sunflower (d) *Dracaena*

262. Largest amount of chloroplast in the leaf is in:
(a) Spongy tissue (b) Palisade tissue
(c) Guard cells (d) Bundle sheath cells

263. What is the characteristic of a monocot stem bundle?
(a) Open and surrounded by a sclerenchymatous bundle sheath
(b) Closed and not surrounded by bundle sheath
(c) Closed and surrounded by bundle sheath
(d) Open and not surrounded by bundle sheath

264. Vascular bundles are surrounded by a sclerenchymatous sheath in: **(Raj. PMT 1991)**
(a) Monocot root (b) Monocot stem
(c) Dicot stem and leaf (d) Dicot root and hypocotyl

265. In dicot root:
(a) Vascular bundles are scattered with cambium
(b) Vascular bundles are open and arranged in a ring
(c) Xylem and phloem are radial
(d) Xylem is always endarch

266. Two exarch vascular bundles are found in: **(CPMT 1993)**
(a) Monocot stem (b) Dicot stem
(c) Monocot root (d) Dicot root

267. Innumerable vascular bundles, lack of cambium, and lack of a well demarcated pith is found in:
(a) Sugar cane (b) Sunflower
(c) Radish (d) Pea

268. The conductive tissue of dicot roots generally form a solid mass in the centre instead of the bundles being dispersed around a broad pith, this contributes to:
(a) Flexibility without loss of tensile strength
(b) Rigidity
(c) Positive gravitropism
(d) Negative geotropism

269. In true hydrophytes the stomata are present on:
(a) Upper epidermis
(b) Lower epidermis
(c) None of the side
(d) Present on both the sides

270. Vascular bundles in a dicot stem are:
(a) Open collateral endarch
(b) Closed collateral endarch
(c) Open collateral exarch
(d) Closed collateral exarch

271. The tissue separating primary xylem and primary phloem of a dicot stem is:
(a) Cork cambium (b) Procambium
(c) Interfascicular cambium (d) Fascicular cambium

272. Vessels and companion cells are absent in the xylem and phloem of : **(Raj. PMT 1990)**
(a) Gymnosperms (b) Pteridophytes
(c) Angiosperms (d) Bryophytes

273. Radial vascular bundles occur in: **(Raj. PMT 1992)**
(a) Stems
(b) Monocot shoots
(c) Monocot root and dicot shoot
(d) Dicot roots and monocot roots

274. T.S. of a material exhibits conjoint collateral, endarch and closed bundles scattered in a ground tissue. What should be the material?
(a) Monocot root (b) Dicot root
(c) Monocot stem (d) Dicot stem

275. In a graft between stock and scion, the structure first developed is: **(CBSE 1990)**
(a) Vascular tissue (b) Wall
(c) Callus (d) Plasmodesmata

276. Periderm is formed from: **(CBSE 1993)**
(a) Vascular cambium (b) Phellogen
(c) Fascicular cambium (d) Interfascicular cambium

277. Three or less than six radial vascular bundles are present in:
(a) Monocot stem (b) Dicot stem
(c) Monocot root (d) Dicot root

278. Well developed pith is found in:
(a) Monocot root and monocot stem
(b) Monocot root and dicot stem
(c) Monocot stem and dicot root
(d) Dicot stem and dicot root

279. A dicot root differs from a monocot root in which of the following?
(a) Presence of piliferous layer
(b) Presence of exodermis
(c) Presence of an ill developed pith
(d) Separate radial vascular bundles

280. Which of the following plant possesses both living and dead mechanical tissues (collenchyma and sclerenchyma)?
(a) Monocot stem (b) Dicot stem
(c) Monocot root (d) Dicot root

*281. In old dicot stems a major part of the wood is filled up with tannins, resins, gums, etc., this part is called:
(a) Heart wood (b) Sap wood
(c) Hard wood (d) Self wood

282. A timber merchant told his customer that log of wood which he was purchasing comes from a 20 years old tree, he told so by inspecting the:
(a) Diameter of log
(b) Thickness of the heart wood
(c) Number of cork layers
(d) Growth rings

283. External protective tissues are:
(a) Cortex and epidermis (b) Cork and pericycle
(c) Cortex and pericycle (d) Cork and epidermis

284. What are parts of a periderm?
(a) Phellogen, periblem, plurome
(b) Dermatogen, cortex, phelloderm
(c) Phellem, phellogen, phelloderm
(d) Periblem, phellogen, phelloderm

285. Cork of commerce is obtained from:
(a) Oak plant (b) Mango plant
(c) *Ficus religiosa* (Peepal) (d) *Pinus*

286. The narrow layer of thin-walled cells which separates the wood from phloem in dicotyledonous plant is called: **(CBSE 1993)**
(a) Endodermis (b) Pericycle
(c) Vascular cambium (d) Cork cambium

287. The dicot root is identified by the presence of: **(CBSE 2002)**
(a) Exarch xylem
(b) 2–6 radial vascular bundles
(c) > 6 radial vascular bundles
(d) Absence of pith and endodermis

288. Dendrochronology is the study of:
(a) Height of a tree
(b) Diameter of a tree
(c) Age of a tree with the help of annual rings
(d) Counting of the number of branches

289. Lenticel and its complementary cells are developed through the activity of:
(a) Phellogen (b) Stelar cambium
(c) Dermatogen (d) Intercalary meristem

290. Which will decay faster if exposed freely to the air? **(CBSE 1993)**
(a) Heart wood
(b) Sap wood
(c) Wood with lot of fibres
(d) Soft wood

291. Polyarch, exarch vascular bundles are the characteristics of: **(CBSE 1990)**
(a) Dicot stem (b) Dicot root
(c) Monocot stem (d) Monocot root

292. Periderm includes:
(a) Cork cambium, cork and secondary cortex
(b) Cork cambium and cork
(c) Cork
(d) Cork and secondary phloem

293. Which plant product is used in the manufacture of a cricket ball?
(a) Phellem of *Quercus* (b) Wood of *Acacia*
(c) Phellem of *Albizzia* (d) Wood of *Tectona*

294. In an isobilateral leaf, the stomata are generally found in:
(a) Upper epidermis (b) Lower epidermis
(c) Both the above (d) None of these

295. Which would do maximum harm to a tree?
(a) Loss of half of its leaves
(b) Loss of half of its branches
(c) Loss of all its leaves
(d) Loss of all its bark

296. Cork cells have a major component of: **(Raj. PMT 1990)**
(a) Lignin (b) Suberin
(c) Pectin (d) Cellulose

297. The trees growing in deserts will:
(a) Show alternate rings of xylem and sclerenchyma
(b) Show distinct annual rings
(c) Not show distinct annual rings
(d) Have only conjunctive tissue and phloem formed by the activity of cambium

298. Lenticels are found in:
(a) Monocot stem (b) Dicot stem
(c) Monocot leaf (d) Dicot root and petiole

299. In older woody tissue, the gaseous exchange takes place through:
(a) Lenticel (b) Hydathode
(c) Stomata (d) Aerenchyma

300. Sap wood differs from heart wood in: **(Raj. PMT 1991)**
(a) Darker and non-conducting
(b) Softer and non-conducting
(c) Lighter and conducting
(d) Harder, darker and less conducting

*301. In trees the growth rings represent: **(AFMC 1990)**
(a) Primary xylem (b) Secondary xylem
(c) Secondary phloem (d) Cambium

302. The formation of distinct annual rings in stem mainly depends upon:
(a) Formation of cork cambia
(b) Contrasting seasonal variations
(c) Uniform climatic conditions
(d) Formation of unequal phloem and xylem

303. Lenticel is a loose mass of cells in cork tissue meant for:
(a) Protection
(b) Respiratory exchange of gases
(c) Absorption of moisture from air
(d) Exclusion of germs

304. In summer season, the cambium:
(a) Dies (b) Becomes more active
(c) Becomes less active (d) Becomes inactive

305. In which of the following there is no differentiation of bark, heart wood and sap wood?
(a) Neem (b) Ashok
(c) Mango (d) Palm

306. Annual rings are the bands of:
(a) Secondary cortex and cork
(b) All secondary vascular tissues
(c) Secondary xylem and xylem rays
(d) Secondary phloem and medullary rays

307. Which of the vascular elements are blocked in winter season by the appearance of calloe?
(a) Tracheids (b) Vessels
(c) Sieve tubes (d) Companion cells

308. Phellogen or cork cambium originates from:
(a) Interfascicular cambium
(b) Intrafascicular cambium
(c) Vascular cambium
(d) Tissue outside the vascular cambium

309. In a monocot stem, the cork cambium develops from the:
(a) Inner cells of the cortex
(b) Outer cells of the cortex
(c) Any cell of the cortex
(d) Does not develop

310. The vascular tissue in which annual rings, vessels and fibres are present should be a:
(a) Protoxylem (b) Metaxylem
(c) Primary xylem (d) Secondary xylem

311. The cork cambium or phellogen usually originates from the:
(a) Inner cells of the cortex
(b) Outer cells of the cortex
(c) Any cell of the cortex
(d) Fascicular and interfascicular cambium

312. In a dicot root the major portion of vascular cambium is derived from:
(a) Pericycle (b) Cortex
(c) Hypodermis (d) Epiblema

313. Cork cambium is an example of: **(CPMT 2002; CET J & K 2002)**
(a) Apical meristem (b) Intercalary meristem
(c) Primary meristem (d) Lateral meristem

314. In dorsiventral leaf, the phloem is present towards:
(a) Lower epidermis (b) Upper epidermis
(c) Both (a) and (b) (d) None of these

315. Girdling or removal of a ring of tissue outside the vascular cambium (*i.e.*, bark) from a tree trunk kills it because:
(a) Water cannot move up
(b) Food does not travel down and root becomes starved
(c) Shoot becomes starved
(d) Annual rings are not produced

316. When secondary growth begins in dicot root what happens first?
(a) Cambial initials between xylem and phloem divide
(b) Cells of the pericycle divide
(c) Anticlinal divisions occur in cambium to make it circular
(d) Cells of conjunctive parenchyma becomes meristematic

317. In dorsiventral leaf, the location of phloem and palisade tissue is:
(a) Adaxial side
(b) Abaxial side
(c) Adaxial and abaxial side respectively
(d) Abaxial and adaxial side respectively

318. Which of the following is not found on leaves?
(a) Lenticels
(b) Hydathodes
(c) Phloem and guard cells
(d) Stomata cells

319. Secondary growth in dicot plants takes place due to the:
(a) Formation of meristematic cells in vascular regions
(b) Development of secondary medullary rays
(c) Thickening of vessels and tracheids
(d) Development and division of meristematic cells in vascular and cortical region

320. Intraxylary phloem is:
(a) Internal phloem (b) Included phloem
(c) External phloem (d) Vestigial phloem

321. Vascular cambium gives rise to:
(a) Only xylem
(b) Only phloem
(c) Xylem and phloem both
(d) Secondary xylem, secondary phloem and vascular rays

322. Intrafascicular cambium is situated :
(a) In between the vascular bundles
(b) Inside the vascular bundles
(c) Outside the vascular bundles
(d) In pith

323. The trunk of a tree increases in girth due to cell division activity in:
(a) Vascular tissue (b) Dermal tissue
(c) Meristematic tissues (d) Supporting tissues

324. Which of the following is responsible for growth in circumference of stem or root?
(a) Cortex (b) Cambium
(c) Xylem (d) Phloem

325. Secondary xylem (or) the youngest layer of secondary xylem in a 5 year old dicot stem lies: **(Raj. PMT 1990)**
(a) Just outside the cambium
(b) Just inside the cambium
(c) Adjacent to pith
(d) Adjacent to cortex

326. The youngest layer of secondary phloem in a dicot stem is:
(a) Inside the primary phloem
(b) Just outside the xylem
(c) Outside vascular cambium
(d) Inside vascular cambium

327. To which question the answer is negative?
(a) Do some epidermal cells have chloroplast
(b) Do each tissue has a characteristic position and structure
(c) Are all dicot leaves dorsiventral
(d) Does the root cortex contain sclerenchyma

328. Why is cambium considered a lateral meristem?
(a) Because it gives rise to lateral branches
(b) Because it causes growth in girth
(c) Because it increases height and diameter of a plant
(d) Because it adds bulk to a plant

329. What is not true about sclereid ? (CBSE 1996)
(a) These are parenchyma cells with thickened lignified walls
(b) These are commonly found in the shells of nuts and in pulp of guava, pear, etc.
(c) These are elongated and flexible with tapered ends
(d) These are also called stone cells

330. Angiosperms have: (AFMC 1996)
(a) Vessels absent (b) Tracheids only
(c) Vessels present (d) Sieve tubes absent

331. Tyloses are found in: (MPPMT 1996)
(a) Secondary xylem (b) Secondary phloem
(c) Callus tissue (d) Cork cells

332. Timber is: (MPPMT 1996)
(a) Secondary phloem (b) Phellem
(c) Secondary cortex (d) Secondary xylem

333. Aerenchyma is formed in the tissue of: (MPPMT 1997)
(a) Sclerenchyma (b) Parenchyma
(c) Phloem (d) None of these

334. Promeristem gives rise to which meristem? (MPPMT 1997)
(a) Secondary (b) Lateral
(c) Primary (d) Apical

335. The meristem which has the property of division in all planes is:
(a) Apical meristem (b) Mass meristem
(c) Plate meristem (d) None of these

336. Companion cells are absent in phloem of angiosperms of:
(a) *Sarcandra* (b) *Austrobaileya*
(c) *Eucalyptus* (d) All of these

337. In families Solanaceae and Brassicaceae, stomata are of type:
(a) Paracytic (b) Anomocytic
(c) Anisocytic (d) Diacytic

338. In some hydrophytes, parenchymatous cells are having sides:
(a) 26 (b) 14
(c) 32 (d) 17

339. Another name of plate collenchyma is:
(a) Tubular (b) Angular
(c) Lamellar (d) Annular

340. Origin of cork-cambium in roots is from:
(a) Cortex (b) Pericycle
(c) Endodermis (d) Phloem

341. Oldest layer of secondary phloem in a dicot stem is present:
(a) Inside epidermis
(b) Inside vascular cambium
(c) Outside vascular cambium
(d) Inside cortex

342. *Nelumbo* leaves are:
(a) Hypostomatic (b) Epistomatic
(c) Amphistomatic (d) All of these

343. Uniseriate layer of cells outside stele in vascular plants is:
(a) Epidermis (b) Endodermis
(c) Pericycle (d) Hypodermis

344. In old trees, secondary wood is impregnated with some extractives, which is called:
(a) Soft wood (b) Sap wood
(c) Duramen (d) Hard wood

345. Which is primary meristematic tissue?
(a) Interfascicular cambium
(b) Cork cambium
(c) Vascular cambium
(d) Intrafascicular cambium

346. Casparian bands are found:
(a) On radial walls of endodermis cells
(b) On tangential walls of endodermis cells
(c) Both (a) and (b)
(d) None of the above

347. Lenticels differ from stomata in:
(a) These are made of green living cells, which can change their size
(b) These are made of non-green, living cells, which can change their size
(c) These are made of dead cells, which can change their size
(d) Made of dead cells, which cannot change their size

348. Bulliform cells are found in the leaves of:
(a) Sunflower (b) Wheat
(c) Tinospora (d) Potato

349. 4 radial vascular bundles are present in: **(CPMT 1997; CBSE 2002)**
(a) Dicot root (b) Monocot root
(c) Dicot stem (d) Monocot stem

350. Quiescent centre occurs: (CPMT 1997)
(a) At the tip of root apices
(b) Just below the top of root apices
(c) At shoot apices
(d) None of the above

351. Tracheids and vessels are related to: (CPMT 1997)
(a) Xylem (b) Phloem
(c) Both (a) and (b) (d) None of these

352. Where the dead parenchyma is present? (CPMT 1997)
(a) They lack nucleus at maturity
(b) They retain their nucleus at maturity
(c) Both (a) and (b)
(d) None of the above

353. Epidermis is:
(a) Rarely many layered (b) Always many layered
(c) Always single layered (d) Rarely single layered

354. Which of the following living cells give the mechanical support and strength to plants? (MPPMT 1997)
(a) Sclerenchyma (b) Phloem
(c) Stone cells (d) Collenchyma

355. Sieve tubes are found in: **(CPMT 1997)**
(a) Xylem (b) Phloem
(c) Cortex (d) Pith

356. What is the main function of xylem? **(CPMT 1997)**
(a) Conduction of water
(b) Conduction of photosynthates
(c) Conduction of minerals
(d) None of the above

357. Healing of wound in plants takes place by activity of: **(CPMT 1997, 98)**
(a) Intercalary meristem (b) Secondary meristem
(c) Apical meristem (d) Lateral meristem

358. Which of the following clogs the xylem vessels?
(a) Tyloses (b) Cystoliths
(c) Hydathode (d) Raphide

359. Protoxylem lacunae are characteristic feature of: **(AMU 1996)**
(a) Underground stem
(b) Climbers
(c) Vascular bundles of stem of grasses
(d) Cladode

360. Which of the following lies in between the bark and wood of a tree trunk? **(Pondicherry 1996)**
(a) Cork cambium (b) Phloem
(c) Vascular cambium (d) Primary cortex

361. If all the lenticels of stem are blocked, the first to die will be: **(AIIMS 1996)**
(a) Roots (b) Leaves
(c) Shoot tips (d) None of these

362. Which of the following tissues have only living cells? **(Pondicherry 1996)**
(a) Vessels (b) Tracheids
(c) Sclerenchyma (d) Rays and parenchyma

363. Annual rings seen in cross section of trees consist of: **(AMU 1996; Manipal 1997)**
(a) Spring wood and autumn wood
(b) Summer wood and winter wood
(c) Heart wood and sap wood
(d) Porous wood and non-porous wood

364. Basic difference between a vessel and a tracheid is in the: **(CET Chandigarh 1996)**
(a) Perforations on end walls
(b) Types of pits
(c) Size and types of pits
(d) Length, wall thickness and lignification

365. The concept envisaging three distinct zones of cells of new tissue builders at the stem and root apices is known as: **(BHU 1997)**
(a) Tunica corpus theory (b) Dermatogen
(c) Meristem theory (d) Histogen theory

366. Which are of the following is responsible for conducting radially water and food materials in the woody stems?
(a) Vessels (b) Xylem fibres
(c) Endodermis (d) Vascular rays

367. The vascular cambium produces xylem on one side and phloem on other because: **(AMU 1997)**
(a) Its interfascicular position
(b) Its multicellular nature
(c) Gravitational force
(d) Difference in supply of hormones on two sides

368. Undifferentiated ground tissue is met within: **(CET Chandigarh 1997)**
(a) Maize stem (b) *Cucurbita* stem
(c) Sunflower stem (d) *Pisum* stem

369. Quiescent centre with a zone of slowly dividing cells in the middle of highly meristematic cells in root apex was recognized by: **(AFMC 1997; Pb. PMT 1997)**
(a) Schmidt (b) Clowes
(c) Hanstein (d) Eames

370. Apical, intercalary and lateral meristems are differentiated on the basis of: **(DPMT 1997)**
(a) Origin (b) Function
(c) Position (d) Development

371. Which is not the primary meristem? **(DPMT 1997)**
(a) Protoderm (b) Periblem
(c) Ground meristem (d) Promeristem

372. Which is true about hard woods? **(BHU 1996)**
(a) Non-porous wood (b) Vessels in abundance
(c) Tracheids primarily (d) More parenchyma

373. Lenticels help in: **(Manipal 1997)**
(a) Food storage (b) Gaseous exchange
(c) Photosynthesis (d) Mineral absorption

374. In monocot stem, vascular bundle is: **(CPMT 1998)**
(a) Closed and collateral (b) Open collateral
(c) Bicollateral (d) Radial

375. A vascular bundle in which the protoxylem is pointing to periphery is called: **(AFMC 1998)**
(a) Endarch (b) Exarch
(c) Radial (d) Closed

376. When phloem and cambium are present on both sides of xylem, the vascular bundle is called: **(AFMC 1998)**
(a) Bicollateral (b) Radial
(c) Concentric (d) Collateral

377. Which of the following meristems is responsible for extrastelar secondary growth in dicotyledonous stem? **(CBSE 1998)**
(a) Phellogen
(b) Intrafascicular cambium
(c) Interfascicular cambium
(d) Intercalary meristem

*378. A leaf primordium grows into adult leaf lamina by means of: **(CBSE 1998)**
(a) At first by apical meristem and later largely by marginal meristems
(b) Apical meristem
(c) Lateral meristem
(d) Marginal meristems.

*379. The roots of angiosperms show exarch xylem and their stems have endarch bundles. These are continuous throughout, the change occurs in: (CBSE 1999)
(a) Epicotyl region [✓ (b) Hypocotyl region]
(c) Upper part of root (d) Lower part of stem

380. In *Cucurbita*, which type of vascular bundles are found in stem? (BHU 1999)
(a) Collateral (b) Bicollateral
(c) Radial (d) None of these

381. Collenchyma differs from parenchyma in: (BHU 1999)
(a) Corners are thickened by lignin
[✓ (b) Corners are thickened by pectocellulose]
(c) Both (a) and (b)
(d) None of the above

382. Which of the following is true for a dicot leaf? (BHU 1999)
[✓ (a) Mesophyll is differentiated into palisade and spongy-parenchyma]
(b) Mesophyll is not differentiated into palisade and spongy parenchyma
(c) Stomata on both surface (Amphistomatic)
(d) None of the above

383. Endodermis is the part of: (BHU 1999)
(a) Epidermis (b) Cortex
(c) Vascular cylinder [✓ (d) None of these]

384. Which of the following is essential for secondary growth? (BHU 1999)
(a) Interfascicular cambium
(b) Intrafascicular cambium
[✓ (c) Both (a) and (b)]
(d) Cortex

385. A component of xylem is: (MPPMT 1999)
(a) Sieve tube (b) Medullary ray
(c) Sclereid (d) Tracheid

386. A group of cells alike in form, function and origin is called: (MPPMT 1999)
(a) Organ (b) Organelle
(c) Tissue (d) None of these

387. Hard, lignified, thick-walled, long and pointed cells in a plant are: (MPPMT 1999)
(a) Parenchyma (b) Sclerenchyma
(c) Sclereids [✓ (d) Sclerenchymatous fibres]

388. Cork cambium in stem is formed by: (CBSE 2000)
(a) Epidermis [✓ (b) Hypodermis or cortex]
(c) Pericycle (d) Endodermis

389. Characteristic of open vascular bundle is: (CPMT 2000)
(a) Presence of cambium
(b) Presence of xylem and phloem
(c) Absence of cambium
(d) None of the above

390. Exarch and polyarch vascular bundles are found in: (MPPMT 2000)
(a) Monocot root (b) Monocot stem
(c) Dicot root (d) Dicot stem

391. Companion cells are associated with: (MPPMT 2000)
(a) Sieve tubes (b) Xylem
(c) Collenchyma (d) Cambium

392. Heart wood helps in: (CET Karnataka 2000)
(a) Ascent of sap (b) Translocation of food
(c) Mechanical support (d) Circulation of solutes

393. Tyloses are the structures found in xylem vessels: (CET Karnataka 2000)
(a) Help in efficient flow of water
(b) Help in efficient flow of nutrients
(c) Function is neutral
(d) All the time hinders the flow of water

394. Match the names of the structures listed under column-I with the functions given under column-II, choose the answer which gives the correct combination of the alphabets of the two columns: (CET Karnataka 2000)

	Column-I (Structure)		Column-II (Function)
A	Stomata	p	Protection of stem
B	Bark	q	Plant movement
C	Cambium	r	Secondary growth
D	Hydathode	s	Transpiration
		t	Guttation

(a) A = t, B = r, C = p, D = s
(b) A = p, B = s, C = t, D = r
(c) A = q, B = s, C = p, D = r
(d) A = s, B = p, C = r, D = t

395. The function of a vessel is: (BHU 2000)
(a) Conduction of food
(b) Conduction of water and minerals
(c) To provide strength
(d) None of the above

396. In which of the following characters a monocot root differs from a dicot root? (BHU 2000)
(a) Open vascular bundle
(b) Large pith
(c) Radial vascular bundles
(d) Scattered vascular bundles

397. Tyloses are: (BHU 2000)
(a) Compound sieve plates
(b) Laticiferous channels
(c) Specialized secretory cells
(d) Tracheal plug which plug the lumen of vessel and tracheids

398. Functional xylem of dicot tree is: (AFMC 2001)
(a) Sap wood (b) Autumn wood
(c) Heart wood (d) Hard wood

399. In which of the following plants sunken stomata are found? (CBSE 2001)
(a) *Nerium* (b) *Hydrilla*
(c) Mango (d) Guava

400. Duramen is: **(CET Karnataka 2001)**
(a) Bark
(b) Periderm
(c) Heart wood
(d) Sap wood

401. In the monocot root we observe: **(CET Karnataka 2001)**
(a) Conjoint, collateral, open polyarch vascular bundle
(b) Exodermis, endarch, tetrarch closed bundles
(c) Suberized exodermis, casparian strip, passage cells, cambium
(d) Suberized exodermis, polyarch xylem, pith

***402.** Which of the following is an epidermal cell containing chloroplast? **(Uttaranchal PMT 2001)**
(a) Hydathode
(b) Stomata
(c) Guard cell
(d) None of these

403. A tissue whose living cells form the mechanical tissue of actively growing organs and whose walls show cellulosic unlignified thickenings often at the corners of its cells is known as: **(Manipal 2001)**
(a) Parenchyma
(b) Sclerenchyma
(c) Chlorenchyma
(d) Collenchyma

404. Vascular cambium of root is an example of which type of meristem? **(AIIMS 2001; BHU 2001)**
(a) Apical
(b) Intercalary
(c) Secondary
(d) Root apical

405. In which of the following secondary growth takes place? **(MPPMT 2001)**
(a) *Riccia*
(b) *Funaria*
(c) *Selaginella*
(d) None of these

406. The vascular bundle in which the central phloem is surrounded by xylem is called: **(MPPMT 2001)**
(a) Bicollateral
(b) Amphivasal
(c) Collateral
(d) Amphicribal

407. Amphivasal vascular bundles are also called: **(CPMT 2002)**
(a) Hydrocentric
(b) Hadrocentric
(c) Endoxylem
(d) Leptocentric

408. Vessels and fibres are found in: **(CET J & K 2002)**
(a) Xylem of angiosperms
(b) Xylem of gymnosperms
(c) Both (a) and (b)
(d) None of these

409. Secondary xylem is: **(CET J & K 2002)**
(a) Wood
(b) Bark
(c) Cork
(d) Bast

410. Cells of parenchymatous tissue are characterized by presence of: **(JIPMER 2002)**
(a) Uniform thickening
(b) Thickening at the corner
(c) Lignified walls
(d) Intercellular spaces

411. Fibres are obtained from: **(JIPMER 2002)**
(a) Xylem, phloem and sclerenchyma
(b) Xylem, phloem, sclerenchyma and epidermis
(c) Xylem, parenchyma and epidermis
(d) Xylem, parenchyma and endodermis

***412.** Starch is mainly manufactured by: **(JIPMER 2002)**
(a) Palisade parenchyma
(b) Spongy parenchyma
(c) Guard cells
(d) Vascular bundle

413. One growth ring of plants consists of: **(CET Karnataka 2002)**
(a) Spring wood and early wood
(b) Only autumn wood
(c) Spring wood and autumn wood
(d) Only spring wood

414. Vessels are the major water conducting cells in: **(CET Karnataka 2002)**
(a) Pteridophytes and gymnosperms
(b) Dicots only
(c) Monocots only
(d) Angiosperms

415. Knot in wood occurs due to: **(BCECE 2002)**
(a) Falling of leaves
(b) Injury
(c) Insect bites
(d) Stem embedded in wood

416. Cotton is: **(DPMT 2001)**
(a) Epidermal tissue system
(b) Vascular tissue system
(c) Meristematic tissue system
(d) Ground tissue system

417. Sieve tubes differ from sieve cells because they: **(DPMT 2001)**
(a) Have sieve pores mainly at end walls
(b) Are shorter
(c) Lack nuclei
(d) Are dead

418. Companion cells are associated with: **(Raj. PMT 2001)**
(a) Tracheids of angiosperms
(b) Vessels of angiosperms
(c) Tracheids of gymnosperms
(d) Sieve tubes of angiosperms

419. Bulliform cells are found in: **(Raj. PMT 2001)**
(a) Seeds of sunflower
(b) Leaf of wheat
(c) Pod of pea
(d) Tuber of potato

***420.** Epidermis and epiblema are produced from: **(BHU 2002)**
(a) Phellogen
(b) Protoderm
(c) Procambium
(d) Calyptrogen

421. Generally, a monocot stem bears: **(BHU 2002)**
(a) Bicollateral closed vascular bundles
(b) Bicollateral open vascular bundles
(c) Collateral open vascular bundles
(d) Collateral closed vascular bundles

422. Vessels are found in: **(CBSE 2002)**
(a) All angiosperms and some gymnosperms
(b) Most of the angiosperms and few gymnosperms
(c) All angiosperms, all gymnosperms and some pteridophytes
(d) All pteridophytes

***423.** Axillary bud and terminal bud are derived from the activity of : **(CBSE 2002)**
(a) Lateral meristem
(b) Intercalary meristem
(c) Apical meristem
(d) Parenchyma

424. For viewing apical meristem which one of the following would be the suitable material? **(MPPMT 2002)**
(a) Onion root tip
(b) Leaf of *Dichanthium*
(c) Rat tail
(d) Flower bud

425. Lignin is the important component of the cell wall of: (MPPMT 2002)
(a) Phloem (b) Xylem
(c) Cambium (d) Parenchyma

426. Grass stem elongates due to: (EAMCET 2002)
(a) Lateral meristem (b) Secondary meristem
(c) Intercalary meristem (d) Apical meristem

427. A simple tissue with mechanical and physiological functions in a young dicotyledonous plant is: (EAMCET 2002)
(a) Parenchyma (b) Collenchyma
(c) Sclerenchyma (d) Meristematic tissue

428. The cells are chlorophyllous, fewer in number, unique in shape and inner walls thick. This description fits into: (EAMCET 2002)
(a) Subsidiary cells (b) Guard cells
(c) Passage cells (d) Bulliform cells

429. Endodermis is a part of: (EAMCET 2002)
(a) Epidermal tissue system
(b) Extrastelar ground tissue system
(c) Intrastelar ground tissue system
(d) Vascular tissue system

430. The type of vascular bundles in the stem of *Dracaena* is: (EAMCET 2002)
(a) Radial (b) Bicollateral
(c) Amphicribal (d) Amphivasal

431. The position of protoxylem in leaf is: (Raj. PMT 2002)
(a) Adaxial
(b) Abaxial
(c) Surrounded by metaxylem
(d) Lateral

432. Meristematic tissue are: (CPMT 2003)
(a) Premature having ability of division
(b) Mature do not have ability of division
(c) Premature not having ability of division
(d) Complex differentiating in xylem, phloem and cambium

433. Numerous vascular bundles are scattered in the ground tissue of: (Orissa JEE 2003)
(a) Monocot stem (b) Dicot stem
(c) Monocot root (d) Dicot root

434. Root hairs are found: (Kerala PMT 2003)
(a) In the zone of elongation
(b) Adventitious roots
(c) On the root tip
(d) Apical meristem
(e) In the zone of maturation

435. In the leaf, vascular bundles are found in the: (Kerala PMT 2003)
(a) Veins (b) Palisade tissue
(c) Lower epidermis (d) Upper epidermis
(e) Spongy mesophyll

436. The layer of cells outside the phloem meant for giving rise to the root branches is called: (Kerala PMT 2003)
(a) Cambium (b) Corpus
(c) Endodermis (d) Radicle
(e) Pericycle

437. Vascular bundles in which phloem is found on both sides of xylem are called: (BV Pune 2003)
(a) Amphicribal (b) Radial
(c) Bicollateral (d) Collateral

438. Aerenchyma is helpful in plants by: (BV Pune 2003)
(a) Giving flexibility to plants
(b) Giving mechanical strength to plants
(c) Promoting photosynthesis
(d) Providing buoyancy in hydrophytes

439. The complex tissue includes: (BV Pune 2003)
(a) Collenchyma (b) Scleroids
(c) Sclerenchyma (d) Secretory tissues

440. Which combination of tissues acts together to provide the support to the hypocotyl of seedling? (BV Pune 2003)
(a) Xylem and phloem fibres
(b) Epidermis and parenchyma
(c) Xylem and parenchyma
(d) Epidermis and collenchyma

441. Diffuse porous woods are characteristic of plants growing in: (CBSE 2003)
(a) Tropics (b) Alpine region
(c) Temperate climate (d) Cold winter regions

442. The apical meristem of the root is present in: (CBSE 2003)
(a) Radicle (b) Tap roots
(c) Adventitious (d) All the roots

443. The cells of the quiescent centre are characterised by: (CBSE 2003)
(a) Dividing regularly to add to tunica
(b) Dividing regularly to add to corpus
(c) Having light cytoplasm and small nuclei
(d) Having dense cytoplasm and prominent nuclei

444. Periderm comprises of: (PMET Punjab 2003)
(a) Phellem (b) Phellogen
(c) Phelloderm (d) All of these

445. Exarch xylem is found in: (PMET Punjab 2003)
(a) Root (b) Stem
(c) Leaf (d) None of these

446. Cambium activity is highest in: (AFMC 2003)
(a) Autumn (b) Spring
(c) Winter (d) Rain

447. Wood is: (AFMC 2003)
(a) Primary phloem (b) Primary xylem
(c) Secondary xylem (d) Secondary phloem

448. In a dicotyledonous stem, the sequence of tissues from the outside to the inside is: (AIIMS 2003)
(a) Phellem–pericycle–endodermis–phloem
(b) Phellem–phloem–endodermis–pericycle
(c) Phellem–endodermis–pericycle–phloem
(d) Pericycle–phellem–endodermis–phloem

449. The quiescent centre in root meristem serves as a: **(AIIMS 2003)**
   (a) Site for storage of food which is utilized during maturation
   (b) Reservoir of growth hormones
   (c) Reserve for replenishment of damaged cells of meristem
   (d) Region for absorption of water

450. In which of the following, there is no differentiation of bark, sap wood and heart wood: **(Manipal 2003)**
   (a) Date palm (b) Neem
   (c) Mango (d) Ashok

451. The innermost layer of cortex which shows casparian thickenings in its cells is called as: **(Manipal 2003)**
   (a) Exodermis (b) Pericycle
   (c) Endodermis (d) Epidermis

452. Meristematic tissues include: **(Manipal 2003)**
   (a) Mature fruits and leaf tips
   (b) Stem and root apices, vascular cambium and cork cambium
   (c) Stem and root apices, cork cambium and mature fruits
   (d) Leaf tips, cork cambium and vascular cambium

ANSWERS

1—b	2—b	3—a	4—a	5—b	6—b	7—a	8—a	9—c	10—d	11—b	12—a
13—b	14—b	15—c	16—c	17—b	18—b	19—b	20—a	21—c	22—c	23—b	24—c
25—b	26—c	27—d	28—c	29—c	30—a	31—c	32—b	33—b	34—b	35—b	36—d
37—a	38—c	39—c	40—b	41—b	42—b	43—a	44—d	45—d	46—c	47—b	48—a
49—c	50—d	51—b	52—a	53—a	54—a	55—b	56—c	57—d	58—b	59—b	60—c
61—b	62—a	63—a	64—c	65—b	66—b	67—a	68—c	69—b	70—c	71—a	72—b
73—a	74—a	75—c	76—a	77—c	78—b	79—b	80—a	81—d	82—b	83—a	84—b
85—b	86—a	87—b	88—b	89—c	90—d	91—b	92—a	93—c	94—a	95—b	96—a
97—a	98—b	99—b	100—a	101—a	102—b	103—b	104—b	105—b	106—c	107—a	108—d
109—d	110—b	111—a	112—a	113—a	114—c	115—c	116—a	117—a	118—b	119—c	120—c
121—b	122—c	123—d	124—b	125—b	126—a	127—c	128—c	129—d	130—c	131—c	132—a
133—d	134—c	135—c	136—c	137—c	138—c	139—b	140—d	141—a	142—b	143—b	144—b
145—c	146—b	147—b	148—c	149—a	150—b	151—c	152—c	153—c	154—d	155—c	156—a
157—d	158—c	159—a	160—b	161—d	162—b	163—c	164—b	165—b	166—c	167—c	168—d
169—a	170—b	171—b	172—a	173—b	174—b	175—b	176—c	177—c	178—c	179—b	180—b
181—c	182—a	183—d	184—c	185—b	186—c	187—b	188—b, c	189—d	190—a	191—d	192—b
193—c	194—a	195—b	196—a	197—a	198—c	199—b	200—c	201—a	202—c	203—b	204—d
205—c	206—d	207—c	208—c	209—a	210—c	211—b	212—b	213—b	214—d	215—c	216—a
217—a	218—d	219—a	220—c	221—b	222—c	223—a	224—b	225—a	226—b	227—c	228—d
229—c	230—b	231—c	232—c	233—a	234—d	235—b	236—c	237—c	238—b	239—a	240—c
241—c	242—b	243—b	244—b	245—a	246—a	247—a	248—b	249—b	250—a	251—a	252—b
253—c	254—d	255—b	256—b	257—d	258—c	259—a	260—b	261—b	262—b	263—c	264—b
265—c	266—d	267—a	268—a	269—c	270—a	271—d	272—a	273—d	274—c	275—c	276—b
277—d	278—b	279—c	280—b	281—a	282—d	283—d	284—c	285—a	286—c	287—b	288—c
289—a	290—b	291—d	292—a	293—a	294—c	295—d	296—b	297—c	298—b	299—c	300—c
301—b	302—b	303—b	304—b	305—d	306—c	307—c	308—d	309—d	310—d	311—b	312—a
313—d	314—a	315—b	316—d	317—d	318—a	319—d	320—a	321—d	322—b	323—c	324—b
325—b	326—c	327—d	328—b	329—c	330—c	331—a	332—d	333—b	334—d	335—b	336—b

337—c	338—d	339—c	340—b	341—d	342—b	343—b	344—c	345—d	346—c	347—c	348—b
349—a	350—a	351—a	352—a	353—a	354—d	355—b	356—a	357—b	358—a	359—c	360—c
361—c	362—d	363—a	364—a	365—d	366—d	367—d	368—a	369—b	370—c	371—d	372—b
373—b	374—a	375—b	376—a	377—a	378—a	379—b	380—b	381—b	382—a	383—d	384—c
385—d	386—c	387—d	388—b	389—a	390—a	391—a	392—c	393—d	394—d	395—b	396—b
397—d	398—a	399—a	400—c	401—d	402—c	403—d	404—c	405—d	406—b	407—d	408—a
409—a	410—d	411—a	412—a	413—c	414—d	415—d	416—a	417—c	418—d	419—b	420—b
421—d	422—b	423—c	424—a	425—b	426—c	427—b	428—b	429—b	430—d	431—a	432—a
433—a	434—e	435—a	436—e	437—c	438—d	439—d	440—d	441—a	442—d	443—c	444—d
445—a	446—b	447—c	448—c	449—c	450—a	451—c	452—b				

Protox°. periphery
– centre

exarch — Root — centripetal
endarch — stem — centrifugal
xylem.

Non Dead cells – Sclerenchyma
Tracheids
Vessels
Fibres.

EXPLANATION OF SELECTED QUESTIONS (*)

20. In root, growth occurs just behind the apex as there is root cap at apex.

29. Proteolytic (protein breaking) enzymes secreting glands are present in insectivorous plants like *Drosera*.

42. Centrifugal or endarch xylem is characteristic of stem.

62. Annual rings are well marked in trees of temperate (cold) regions (as Shimla).

63. Cambium is absent in monocots and hence grafting is not possible.

76. Loosely arranged cells of a lenticel are called complementary cells.

86. Protoxylem is first formed xylem and hence more mature than metaxylem.

100. In monocot stem, instead of well defined cortex and pith, there is present ground tissue.

157. No reserve food materials like fats, proteins and sugars are present in meristematic cells.

163. Epithem is a loose tissue of hydathode, which is related with guttation.

176. Idioblasts are mucilage (waste) containing cells.

227. Vessel is a composite structure formed by dissolution of end walls of row of vessel elements (while tracheid is an individual cell).

281. The older portion of wood is filled with tannins, resins, gums, etc., called heart wood.

301. In growth rings, secondary xylem (wood) is present, which is cut-off by vascular cambium.

378. The leaf primordium has an apical meristem at its tip, which becomes inactive at early stage of development. Further increase in length occurs by intercalary meristem. Simultaneously marginal meristem (cells of margin of leaf axis) divide and redivide to form leaf lamina.

379. Root-stem transition occurs in hypocotyl region of axis.

402. Guards cells are the specialized epidermal cells containing chloroplasts.

412. Starch is mainly manufactured by palisade parenchyma due to presence of numerous chloroplasts.

420. Outermost meristematic layer of the young growing region is known as protoderm and it develops into epidermis and epiblema.

423. Axillary or lateral bud is a cluster of dormant meristem cells left behind by the apical meristem as the stem grows. The terminal bud includes the apical meristem and several leaf primordia produced by meristem.

TEST PAPER–UNIT-5

1. Which of the following constitutes the dominant flora of nowadays?
(a) Bryophyta (b) Pteridophyta
(c) Angiosperms (d) Gymnosperms

2. Miny or tiny future plant present in a seed is:
(a) Ovule (b) Cotyledon
(c) Embryo (d) Embryo sac

3. Woody plant branched near the ground and stem is not much developed into clear trunk, is called:
(a) Herb (b) Shrub
(c) Tree (d) Palm

4. Which of the following is deliquescent or decurrent tree?
(a) *Ficus* (b) *Tamarindus*
(c) *Mangifera* (d) All of these

5. Century plant is:
(a) *Bambusa bambos* (b) *Agave americana*
(c) *Argemone mexicana* (d) None of these

6. A plant that is all root, is:
(a) *Utricularia* (b) *Ceratophyllum*
(c) *Podostemon* (d) *Myriophyllum*

7. Adventitious roots arising from leaf are found in:
(a) *Pothos* (b) *Ficus*
(c) *Bryophyllum* (d) *Triticum*

8. Fusiform tap root is found in:
(a) Carrot (b) Radish
(c) Turnip (d) None of these

9. Fasciculated adventitious roots are present in:
(a) *Dahlia* (b) *Asparagus*
(c) *Ruellia* (d) All of these

10. Tunicated bulbs are found in :
(a) Onion (b) Garlic
(c) Both (a) and (b) (d) None of these

11. Suckers are present in:
(a) *Mentha* (b) *Chrysanthemum*
(c) Both (a) and (b) (d) None of these

12. Winged petiole is characteristic of:
(a) *Citrus* (b) *Nepenthes*
(c) *Eichhornia* (d) All of these

13. Dicotyledonous leaves having parallel venation are in:
(a) *Eryngium* (b) *Calophyllum*
(c) Both (a) and (b) (d) None of these

14. Leaf hooks are present in:
(a) *Bignonia unguiscati* (b) *Utricularia*
(c) *Parkinsonia* (d) *Salvinia*

15. Strophiole or caruncle is characteristic of seeds of:
(a) Castor (b) Maize
(c) Wheat (d) Tamarind

16. Hypogeal seed germination occurs in:
(a) Maize (b) Gram
(c) Mango (d) All of these

17. Longest seed viability is reported in:
(a) *Nelumbo nucifera* (b) *Lactuca sativa*
(c) *Xanthium* (d) *Brassica campestris*

18. Pericarp of fruit develops from:
(a) Integuments (b) Testa
(c) Tegmen (d) Ovary wall

19. Porous dehiscence of fruits occurs in:
(a) *Calotropis* (b) Papaver
(c) *Eucalyptus* (d) *Ricinus*

20. Follicle fruit is found in:
(a) *Calotropis* (b) *Brassica*
(c) *Argemone* (d) *Datura*

21. Characteristic fruit of family Umbelliferae (Apiaceae) is:
(a) Regma (b) Cremocarp
(c) Lomentum (d) Carcerulus

22. Pome is a:
(a) True fruit (b) Spurious fruit
(c) Schizocarpic fruit (d) Composite fruit

23. One seeded fruit developing from superior monocarpellary ovary and pericarp fused with seed coat, is called:
(a) Achene (b) Caryopsis
(c) Nut (d) Samara

24. Banana fruit is:
(a) Berry (b) Drupe
(c) Pome (d) Nut

25. Fruit present in mulberry is:
(a) Sorosis (b) Syconus
(c) Simple fruit (d) Aggregate fruit

26. Hypanthodium inflorescence develops into fruit:
(a) Amphisarca (b) Composite
(c) Syconus (d) Sorosis

27. Unicellular juicy hairs from endocarp form edible part of fruit in:
(a) *Litchi* (b) Lemon
(c) Walnut (d) Mulberry

28. 'Tiger's nail' is:
(a) *Xanthium* (b) *Martynia*
(c) *Tribulus* (d) *Aristida*

29. Jaculator mechanism of seed dispersal occurs in:
(a) *Andrographis* (b) *Barleria*
(c) *Ruellia* (d) All of these

30. Sticky fruits occur in:
(a) *Boerhaavia* (b) *Plumbago*
(c) *Viscum* (d) Both (a) and (b)

31. Sexuality in plants was discovered by:
(a) Theophrastus (b) Kolreuter
(c) Camerarius (d) Hofmeister

32. Fertilization phenomenon was first discovered by Strasburger in:
(a) *Monotropa* (b) *Lilium*
(c) *Fritillaria* (d) *Phoenix*

33. Innermost parietal layer of anther having cells with large nuclei and dense cytoplasm, is called:
    (a) Endothecium (b) Tapetum
    (c) Endothelium (d) Pollen kitt
34. Pollen kitt is additional layer of pollen grains in:
    (a) Anemophilous plants
    (b) Zoophilous plants
    (c) Entomophilous plants
    (d) Hydrophilous plants
35. Which of the following is secretion of tapetum?
    (a) Callase enzyme
    (b) Ubisch bodies
    (c) Pollen kitt substances
    (d) All of the above
36. The point of attachment of stalk (funicle) to the body of ovule is called:
    (a) Hilum (b) Caruncle
    (c) Aril (d) Funiculus
37. Ovular structure directing the growth of pollen tube towards micropyle is called:
    (a) Hilum (b) Chalaza
    (c) Obturator (d) Perisperm
38. Most primitive and simple type of ovules in angiosperms is:
    (a) Anatropous (b) Orthotropous
    (c) Amphitropous (d) Circinotropous
39. Synergids are present at which end of embryo sac?
    (a) Micropylar end (b) Chalazal end
    (c) In centre (d) Lateral position
40. The cytoplasm of synergids is:
    (a) Weekly polarized (b) Strongly polarized
    (c) Antipodals (d) Polar nuclei
42. Pollination in angiosperms takes place at how many celled stage of pollen?
    (a) Always at 2-celled stage
    (b) Mostly at 2-celled and rarely at 3-celled stage
    (c) Mostly at 3-celled and rarely at 2-celled stage
    (d) Always at 3-celled stage
43. Tetrasporic embryo sac which is similar to normal monosporic type in structure, is:
    (a) *Adoxa* type (b) *Plumbago* type
    (c) *Pepromea* type (d) *Allium* type
44. Self pollination is a rule in:
    (a) Chasmogamous flowers
    (b) Cleistogamous flowers
    (c) Both (a) and (b)
    (d) None of the above
45. Fly trap mechanism of pollination occurs in:
    (a) *Salvia* (b) *Aristolochia*
    (c) *Ficus* (d) *Ophrys*
46. Which is wrong regarding meristematic cells?
    (a) Are isodiametric
    (b) Have thick cellulosic walls
    (b) Have no intercellular spaces
    (d) Have no reserve food
47. Living and thick-walled cells constitute:
    (a) Parenchyma (b) Collenchyma
    (c) Sclerenchyma (d) Chlorenchyma
48. Layer of barrel shaped cells in mainly roots containing starch constitute:
    (a) Epidermis (b) Endodermis
    (c) Pericycle (d) Medulla
49. Multilayered and sclerenchymatous pericycle is present in:
    (a) *Smilax* root (b) *Ficus* root
    (c) *Yucca* root (d) None of these
50. Annual rings in stem are more conspicuous in:
    (a) Tropical region (b) Sub-tropical region
    (c) Temperate region (d) Same in all of these
51. Areas with loosely arranged cells in periderm constitute:
    (a) Rhytidome (b) Lenticels
    (c) Stomata (d) Tyloses

ANSWERS

1—c	2—c	3—b	4—d	5—b	6—c	7—c	8—b	9—d	10—a	11—c	12—a
13—c	14—a	15—a	16—d	17—a	18—d	19—b	20—a	21—b	22—b	23—b	24—a
25—a	26—c	27—b	28—b	29—d	30—d	31—c	32—a	33—b	34—c	35—d	36—a
37—c	38—b	39—a	40—b	41—a	42—b	43—a	44—b	45—b	46—b	47—b	48—b
49—a	50—c	51—b									

UNIT-5

ASSERTION AND REASON TYPE QUESTIONS

In the questions given below, two statements—an Assertion (A) and a Reason (R) are given. Give the appropriate response as:

(a) If both A and R are true and R is the correct explanation of A.
(b) If both A and R are true and R is not correct explanation of A.
(c) If A is true but R is false.
(d) If both A and R are false.
(e) If A is false but R is true.

1. **A :** Androecium and gynoecium are necessary whorls of the flower.
   R : Androecium and gynoecium are male and female reproductive organs respectively.
2. **A :** A typical angiospermic plant is sporophytic ($2n$).
   R : The gametophytic phase in angiosperms is reduced and parasitic upon sporophytic phase.
3. **A :** In angiosperms, seeds are present inside fruit.
   R : The ripened ovary forms fruit and ripened ovules form seeds.
4. **A :** Embryo is the most important part of the seed.
   R : Embryo is the future miny or tiny plant present inside the seed.
5. **A :** Biennials complete their life cycle in two growing seasons.
   R : They complete their vegetative phase in first season and reproductive phase in second season.
6. **A :** *Podostemon* is a plant that is all root.
   R : Root performs the function of assimilation and reproduction in *Podostemon.*
7. **A :** The plants producing flowers and fruits every year are called monocarpic.
   R : *Agave americana* and *Bambusa* are monocarpic plants.
8. **A :** The root developing from radicle is called tap root.
   R : The conical root present in carrot is adventitious root.
9. **A :** Onion is a tunicated bulb.
   R : Characteristic smell of onion is due to presence of allyl sulphide.
10. **A :** Banana plant is a herb.
    R : Sheathing leaf bases form a pseudostem in banana.
11. **A :** Arrangement of main vein and its branches in leaf is called vernation.
    R : Parallel venation is characteristic of dicotyledons.
12. **A :** A specific outgrowth present over hilum in castor seed is called strophiole.
    R : Strophiole helps in gaseous exchange.
13. **A :** Fruits which are developed from ovary are called true fruits.
    R : Apple and pear are true fruits.
14. **A :** Sorosis fruit develops from hypanthodium inflorescence.
    R : Pineapple and jackfruit are examples of Syconus fruit.
15. **A :** Censer mechanism of seed dispersal occurs in *Papaver* (poppy).
    R : Seeds of poppy are scattered after dehiscence of fruit when shaken by wind.
16. **A :** Discovery of syngamy was made by Strasburger.
    R : Actual fusion of male gamete with female gamete was discovered by Strasburger is *Monotropa.*
17. **A :** Innermost parietal layer of anther is called tapetum.
    R : DNA content is enormously decreased in tapetal cells.
18. **A :** Tepetum is the layer which secrets both enzymes and substance of hormonal nature.
    R : Callase enzyme, ubisch-bodies and pollen kitt substances are secreted by tapetum.
19. **A :** Pollens are preserved for a long time in fossils.
    R : Sporopollenin is the chief component of exine of microspore.
20. **A :** Pollen with pollen tube is fully developed male gametophyte in angiosperms.
    R : Male gametophyte in angiosperms is 8-nucleated.
21. **A :** Integumented indehiscent megasporangium is called ovule.
    R : Nucellus forms the main body of the ovule.
22. **A :** Female gametophyte in angiosperms is 3-nucleated structure.
    R : Egg is the constant feature of female gametophyte of angiosperms.
23. **A :** Double fertilization is universal feature of angiosperms.
    R : Out of two male gametes released from pollen tube, one fuses with egg cell to form zygote and second fuses with 2 polar nuclei to form primary endosperm nucleus in angiosperms.
24. **A :** Nocturnal flowers are pollinated by moths.
    R : Nocturnal flowers are highly fragrant and dull in colour.

25. A : Endosperm is a characteristic storage tissue, which supplies nutrition to the developing embryo.
R : Development of endosperm is from primary endosperm nucleus.

26. A : Polyembryony phenomenon is more common in gymnosperms than angiosperms.
R : In angiosperms, polyembryony is generally present as unusual feature.

27. A : Tissue culture is based upon totipotency concept.
R : Each and every plant cell has inherent capacity to develop into complete plant.

28. A : Most important use of protoplast culture is triploid plant production.
R : Genetic engineering is possible through protoplast culture.

29. A : Synergids of embryo sac help in fertilization in angiosperms.
R : Filiform apparatus of synergids secret certain chemotropically active substances due to which pollen tube grows towards the embryo sac.

30. A : Group of continuously dividing cells is called meristem.
R : Cells of meristem are isodiametric and thin-walled.

31. A : Apical meristem is responsible for increase in length.
R : Vascular cambium and cork cambium are examples of apical meristem.

32. A : Tunica and corpus are two portions in the shoot apex.
R : Tunica divides only anticlinally while corpus divides both anticlinally as well as periclinally.

33. A : Xylem is complex permanent tissue.
R : Four types of cells—vessels, tracheids, xylem parenchyma and xylem fibres form xylem.

34. A : In dicot stem, the vascular bundles are open.
R : Cambium is present between xylem and phloem of vascular bundle in dicot stem.

35. A : Loosely arranged areas in the periderm are called lenticels.
R : Lenticels are characteristic of woody stem.

36. A : Cork cells are dead and buoyant.
R : Cork cells are suberized.

37. A : Collenchyma is thick-walled dead tissue. (AIIMS 2002)
R : Collenchyma is thickened due to deposition of cellulose and pectin.

38. A : Sclerenchyma is thick-walled tissue which is dead.
R : Sclerenchyma has deposition of lignin on their walls.

39. A : The two cotyledones in the seed are the embryonic leaves. (AIIMS 2002)
R : The embryo contains radicle and plumule.

40. A : The megaspore mother cell undergoes mitosis to produce four megaspores. (AIIMS 2002)
R : Megaspore mother cells are diploid but the megaspores are haploid.

41. A : All tissues lying inside the vascular cambium is called as bark. (AIIMS 1994)
R : Bark is made up of phellogen, phellem and phelloderm lying inside the secondary phloem.

42. A : Flowers of the angiosperm perform the function of sexual reproduction. (AIIMS 1994)
R : The male and female reproductive structure are found in the flowers.

43. A : Fusiform initials are elongated cells with pointed ends. (AIIMS 1996)
R : Fusiform initials are made up of ray initials.

44. A : The abscission zone is delimited by a separation layer on the stem side. (AIIMS 1997)
R : It is a special zone of cells formed at the base of petiole which help in abscission of leaves.

45. A : In hemianatropous type of ovule, the funicle lies parallel to the body of ovule. (AIIMS 1999)
R : Here the body of ovule has rotated through 90°.

46. A : In collateral vascular bundles phloem is situated towards the inner side. (AIIMS 2000)
R : In monocot stem, the cambium is present.

47. A : Seeds should be heavy and smooth so that they can travel large distances for dispersal. (AIIMS 2000)
R : For dispersal by wind fruits and seeds should be light.

48. A : Many crop plants are propagated vegetatively even though they can bear seed. (AIIMS 2001)
R : Potatoes are multiplied by tubers, apple by cutting and strawberries by runners.

49. A : In plant tissue culture somatic embryo can be induced from any plant cell. (AIIMS 2003)
R : Any viable plant cell can differentiate into somatic embryos.

ANSWERS

1. (a) 2. (b) 3. (a) 4. (a) 5. (a) 6. (a) 7. (c) 8. (c) 9. (b) 10. (a)
11. (d) 12. (c) 13. (c) 14. (d) 15. (a) 16. (a) 17. (c) 18. (a) 19. (a) 20. (c)
21. (b) 22. (c) 23. (a) 24. (a) 25. (b) 26. (a) 27. (a) 28. (c) 29. (a) 30. (b)
31. (c) 32. (b) 33. (a) 34. (a) 35. (b) 36. (a) 37. (c) 38. (a) 39. (b) 40. (c)
41. (d) 42. (a) 43. (c) 44. (c) 45. (c) 46. (d) 47. (c) 48. (a) 49. (a)

UNIT-6

- Taxonomy of Angiosperms or Systematic Botany
- Plants and Human Welfare
- Test Paper—Unit–6
- Assertion—Reason Type Questions (Unit–6)

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19

Taxonomy of Angiosperms or Systematic Botany

- Meaning
- Nomenclature
- Binomial system of nomenclature
- International code of botanical nomenclature
- Classification of angiosperms
- Herbarium
- Botanical gardens
- Botanical survey of India
- Important taxonomic terms
- Families—Brassicaceae, Malvaceae, Leguminosae (Papilionaceae, Caesalpiniaceae, Mimosaceae), Cucurbitaceae, Compositae, Solanaceae, Liliaceae
- Main points of some other important families (Ranunculaceae, Poaceae)

Taxonomy is the branch of botany which deals with (a) Identification, (b) Nomenclature and (c) Classification of plants.

The term Taxonomy has been derived from two Greek words (*taxis* – arrangement + *nomous* – law or rule), *i.e.*, arrangement of plants (organisms) following some laws or rules.

- The term Taxonomy was first given by a French botanist **A. P. de Candolle (1813).**
- **Carolus Linnaeus** (Swedish botanist) is called 'father of Taxonomy' or **father of Systematic botany.** (H. Santapau-father of Indian Taxonomy).
- Term **'Systematics'** was given by **C. Linnaeus** and is used for taxonomy.

In fact term Systematics includes taxonomy and phylogeny, *i.e.*, identification, nomenclature, classification and evolutionary relationships.

- Taxonomy is also called **Systematic botany.**

Alpha taxonomy

Identification and classification of plants on the basis of only morphological characters is called **Alpha taxonomy,** a term given by **Turill** (1938).

Beta taxonomy

β-taxonomy of Turill involves not only gross morphological features, but also genetical, anatomical, cytological, palynological (pollens and spores study), physiological and other characters. It is also called **Biosystematics.**

○ Term **New Systematics** was given by **Julian Huxley** (1940) for Systematics or taxonomy in which characters of plants (organisms) collected through different branches of science are taken into consideration, *e.g.*, **chemotaxonomy** (chemical components in relation to taxonomy, **cytotaxonomy** (cytology in relation to taxonomy) and numerical taxonomy, etc.

NOMENCLATURE

Nomenclature is defined as system of naming objects (plants and animals).

- Need of scientific names was felt because the same plant is having different common names in different parts of world.
- The earliest scientific names were **polynomials,** *i.e.*, names composed of several words. It was very difficult to remember these difficult long names.

BINOMIAL SYSTEM OF NOMENCLATURE

It was given by Swedish botanist **Carolus Linnaeus** (father of taxonomy) in his book **Species Plantarum** (1753).

According to this system, each plant (organism) is given a name made of two **Latin** or **Latinized** words.

- The first word represents the genus and is called generic name or generic epithet (Noun), whereas the second word represents species and is called specific name or specific epithet (Adjective).
- The generic epithet always starts with capital letter and specific epithet starts with small letter.
- Both these names are **underlined separately.** (Italicized separately; if printed).
- The generic and specific names may be based on the name of any scientist or on some characters of plant or on some legend.
- Generally the name of **author,** giving the name is written after specific epithet in abbreviated form or in full. This is called **Authority** (Neither underlined nor italicized), *e.g.*, scientific names of some plants on the basis of binomial system of nomenclature of Linnaeus are as:

Mango — *Mangifera indica* L.

(*Mangifera*—Generic name; *indica*—Specific name; Linnaeus—Authority)

Similarly,

Coffee — *Coffea arabica* L.
Potato — *Solanum tuberosum* L.
Siris — *Albizzia lebbeck* (L.) Benth, *i.e.*, first described by Linnaeus and later corrected by Bentham.

- (No comma, hyphen, etc., between specific name and authority).
- The different names given to same species by different workers are called **Synonyms, but the name given first is considered to be valid.**
- Binomials are more precise and definite than common names. Further these are internationally accepted as Latin is internationally known by scholars.

INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE

The foundations of International code of botanical nomenclature are found in **Philosophia Botanica,** a book written by **C. Linnaeus.**

- Current International code of botanical nomenclature appeared in 1978.

Main points of this code are as follows:

(i) Botanical nomenclature is independent of zoological nomenclature.

(ii) The word **Taxa** (Singular-Taxon) represents **'taxonomic groups of any rank',** *i.e.*, any unit of classification.

- The rank of species is basic and relative order of the ranks of taxa are:

Species, genus, tribe, family, order, series, class, division and kingdom.

These categories or ranks are ranked one above the other, called **'Hierarchy'. 'Kingdom'** is the highest and 'species' is the lowest category in this **hierarchy.**

unit of classification
i.e.

- According to International code of botanical nomenclature, different ranks or categories have following specific 'endings' of their names:

Rank of category	Ending of name
Division	phyta
Subdivision	phytina
Class	ae
Order	ales
Sub-order	ineae
Family	aceae
Subfamily	oideae

(iii) Name of families : According to International code, name of a family is a **plural adjective** and is formed by adding suffix-'aceae' to the name of an included genus in that family, *e.g.*, Solanaceae (from *Solanum*).

- Special mention is of following eight families, where new names (ending with 'aceae') have been given according to International code of botanical nomenclature, although due to long usage, old names of these families are still valid.

	Old names	New names
1.	Gramineae	Poaceae
2.	Palmae	Arecaceae
3.	Cruciferae	Brassicaceae
4.	Guttiferae	Clusiaceae
5.	Leguminosae	Fabaceae
6.	Labiatae	Lamiaceae
7.	Compositae	Asteraceae
8.	Umbelliferae	Apiaceae

(iv) Name of species : It is binary combination in which generic epithet is followed by specific epithet.

It is important to note that if an epithet consists of two or more words, these are to be **united with the help of hyphen,** *e.g.*, *Trigonella foenum-graecum.*

Similarly, *Hibiscus rosa-sinensis.*

IV

- The **tautonyms** are altogether **illegitimate** in botanical nomenclature, *i.e.*, specific epithet should not be exactly the generic epithet in botanical names. However the **tautonyms** (where generic and specific epithets are same) are valid in **zoological nomenclature,** *e.g.*, *Linaria linaria.*

(v) Typification : The names of taxa of the category (rank) of family and below is determined by means of **nomenclatural type,** which is that element with which name is permanently associated. The type of species is an individual specimen, whereas type of genus is a species and that of family is a genus.

Following are the types:

(a) Holotype : It is the specimen or element (figure or description) which is designated as nomenclatural type by the author.

(b) Isotype : If several plants are collected at the same time, one is the holotype and others are designated as isotypes, *i.e.*, isotype is duplicate of holotype.

Species کی ٹائپ ایک فرد ہوتا ہے [illegible]
Genus کی ٹائپ ایک [illegible] Species [illegible]

(c) Lectotype : When no holotype is designated by the author at the time of publication or holotype is missing, then the specimen or element selected from the original material to serve as nomenclatural type is called lectotype.

(d) Syntype : It is any one of two specimen cited by the author as nomenclatural type.

(e) Neotype : When all the material on which description of new species was based is missing, then the new specimen or element selected to serve as nomenclatural type is called neotype.

(vi) Priority principle : When many names are given to the same species, then the name under which the species was first described is valid, provided the publication is effective and valid, *i.e.*, a taxon can have one correct name.

- ○ Date of valid publication is considered to be beginning from May 1, 1753 (date of publication of Species Plantarum of Linnaeus).

CLASSIFICATION OF ANGIOSPERMS

Classification means arrangement of plants into different groups and subgroups on the basis of origin, relationships and extent of similarities and dissimilarities. Floral characters are mainly used in classification and identification in angiosperms because reproductive parts (floral parts) are more **stable and conservative** than vegetative parts.

There are 3 main systems of classification of plants– Imp

1. Artificial system of classification,
2. Natural system of classification and
3. Phylogenetic system of classification.

1. Artificial system of classification

Artificial system is that in which plants are classified on the basis of one or few important characters.

- Earliest systems of classification were **artificial** systems and these remained dominant from 300 B.C. to 1830 A.D.
- Important advocates of artificial systems are as follows:

Theophrastus (370–285 B.C.) was a Greek naturalist and he is known as **father of Botany.** He was **initiator** of plant classification or Systematic botany.

- He first of all gave an artificial system of classification on the basis of habit, *i.e.*, **herbs, undershrubs, shrubs and trees.**
- He also first of all distinguished between **annuals, biennials and perennials.**
- He gave names and description of about **500 plants** in his book, **Historia Plantarum,** which is oldest botanical book in existence.
- Some other workers of this era were:

Dioscorides, Andrea Caesalpino, John Ray, Camerarius and above all **Linnaeus.**

- ○ **Camerarius** was the person, who first recognized **sexuality in plants.**
- **John Ray** introduced the term **'Species'.**

Carolus Linnaeus (1707 – 1778)– A great Swedish naturalist called **father of Taxonomy** or **father of Modern Botany.** He was born in 1707 in a small village Rashult in S. Swedon.

- In university of Uppsala, he published his first paper on **sexuality in plants** (1729) under Dr. Olof Rudbeck.
- Important books of Linnaeus– **Systema Naturae, Hortus Uplandicus, Hortus Cliffortianus, Genera Plantarum, Philosophia Botanica** and **Species Plantarum.**
- In **Species Plantarum**, 7300 species of plants are classified and described on the basis of sexual characters or **characters of stamens**, *i.e.*, number, size, form and union of stamens.
- Sometimes this classification of Linnaeus is called **Sexual System of Classification.**
- In this classification, plants known to him are divided into following 24 classes or groups:

1. Monoandria — 1 stamen
2. Diandria — 2 stamens
3. Triandria — 2 ''
4. Tetrandria — 4 ''
5. Pentandria — 5 ''
6. Hexandria — 6 ''
7. Heptandria — 7 ''
8. Octandria — 8 ''
9. Enneandria — 9 ''
10. Decandria — 10 ''
11. Dodecandria — 11–19 ''
12. Icosandria — 20 or more stamens, attached to calyx.
13. Polyandria — 20 or more stamens, attached to receptacle.
14. Didynamia — Didynamous condition (2 long + 2 short stamens)
15. Tetradynamia — Tetradynamous condition (4 long + 2 short stamens)
16. Monoadelphia — Monoadelphous condition
17. Diadelphia — Diadelphous condition
18. Polyadelphia — Polyadelphous condition
19. Syngenesia — Syngenesious condition
20. Gynandria — Stamens attached to gynaecium
21. Monoecia — Monoecious condition of plants
22. Dioecia — Dioecious plants
23. Polygamia — Polygamous condition, *i.e.*, both unisexual and bisexual flowers on the same plant.
24. Cryptogamia — Hidden flowers, *i.e.*, algae, fungi, bryophytes and pteridophytes.

The main demerit of this classification is that two plants, which are similar in many characters are separated merely on the basis of a single character, *i.e.*, **this classification is based on dissimilarity rather than similarity.**

2. Natural system of classification

Natural system is that in which classification is made on the basis of all available natural characters.

- More emphasis was given on natural system of classification after Linnaeus.
- **B. L. de Jussieu** of France was the first advocate of this system, who was followed by **A. L. de Jussieu** and **Robert Brown. A.P. de Candolle**, a French botanist

again gave a natural system of classification in which 161 families of angiosperms have been given.

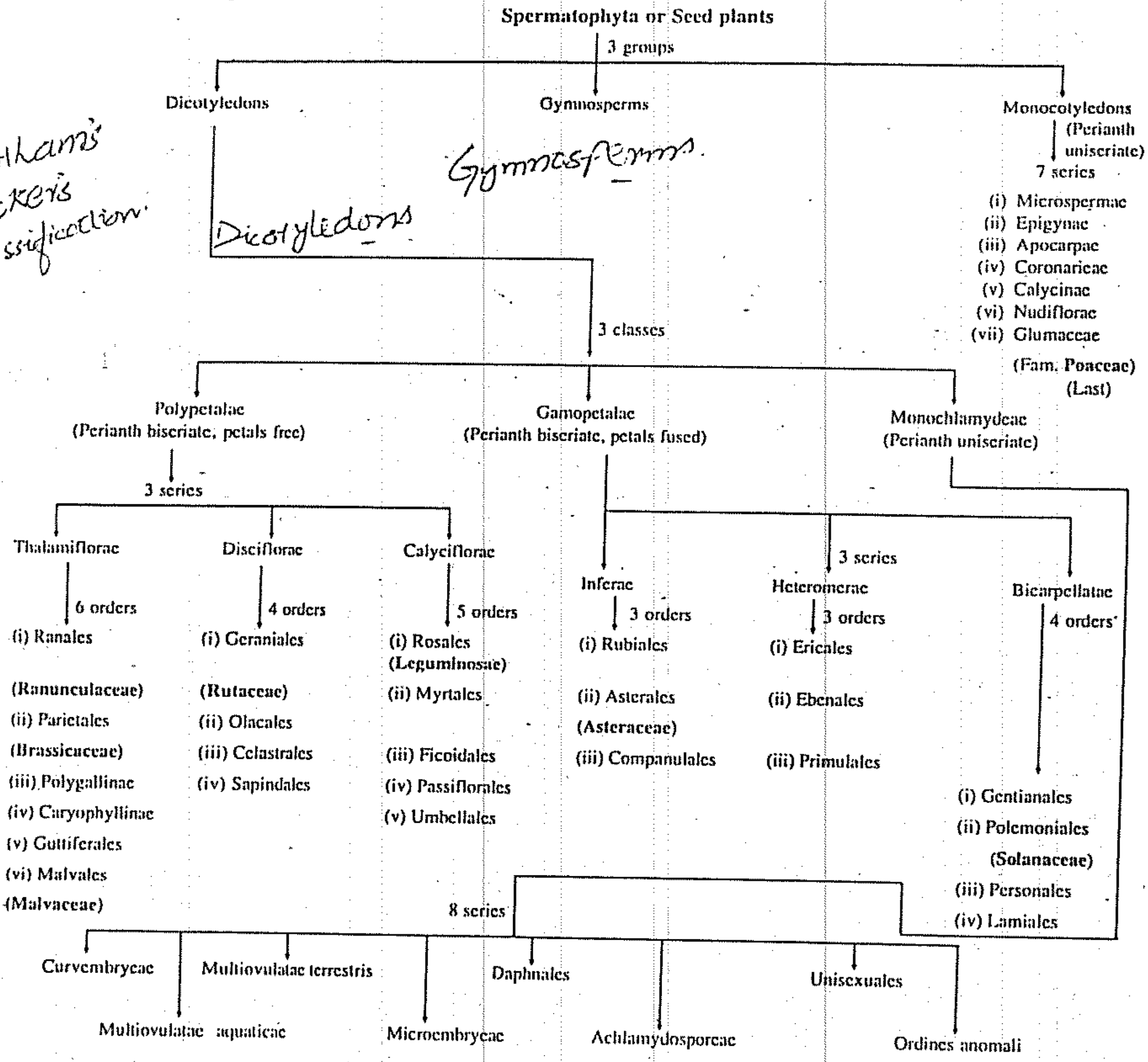
- The most important classification of this era was by Bentham and Hooker (1862 – 83). This was the last natural system of classification and this classification was not affected by concept of evolution, although it was given after publication of Darwin's theory of evolution.

Bentham's and Hooker's classification

George Bentham (1800–1884) and **J. D. Hooker** (1817–1911) were English botanists and both of them were working in Royal Botanical Garden, Kew, England (Largest botanical garden in the world).

- **J. D. Hooker** was more plant explorer and geographer than Bentham.
- Bentham and Hooker gave their natural system of classification in 3-volumes of **Genera Plantarum** (Ist vol. in 1862 and last in 1883). In this classification they arranged and classified all plants known at that time according to natural system, *i.e.*, on the basis of all available natural characters or natural affinities.
- Brief outline of this classification is as:

ntham's
ooker's
lassification


Spermatophyta or Seed plants
3 groups
Dicotyledons
Gymnosperms
Monocotyledons
(Perianth uniseriate)
7 series
(i) Microspermae
(ii) Epigynae
(iii) Apocarpae
(iv) Coronarieae
(v) Calycinae
(vi) Nudiflorae
(vii) Glumaceae
(Fam. Poaceae)
(Last)
Gymnosperms
Dicotyledons
3 classes
Polypetalae
(Perianth biseriate, petals free)
Gamopetalae
(Perianth biseriate, petals fused)
Monochlamydeae
(Perianth uniseriate)
3 series
Thalamiflorae
6 orders
(i) Ranales
(Ranunculaceae)
(ii) Parietales
(Brassicaceae)
(iii) Polygallinae
(iv) Caryophyllinae
(v) Guttiferales
(vi) Malvales
(Malvaceae)
Disciflorae
4 orders
(i) Geraniales
(Rutaceae)
(ii) Olacales
(iii) Celastrales
(iv) Sapindales
Calyciflorae
5 orders
(i) Rosales
(Leguminosae)
(ii) Myrtales
(iii) Ficoidales
(iv) Passiflorales
(v) Umbellales
3 series
Inferae
3 orders
(i) Rubiales
(ii) Asterales
(Asteraceae)
(iii) Companulales
Heteromerae
3 orders
(i) Ericales
(ii) Ebenales
(iii) Primulales
Bicarpellatae
4 orders
(i) Gentianales
(ii) Polemoniales
(Solanaceae)
(iii) Personales
(iv) Lamiales
8 series
Curvembryeae
Multiovulatae aquaticae
Multiovulatae terrestris
Microembryeae
Daphnales
Achlamydosporeae
Unisexuales
Ordines anomali

- In this classification, they gave 202 families of angiosperms. Further they have described 97,205 species of 7,569 genera.
- They have placed gymnosperms between two groups of angiosperms.
- The families begin with Ranunculaceae and end with Gramineae (Poaceae).
- This system of classification is widely accepted in Britain and its common wealth countries, but is not so accepted in Europe, North America, Germany, etc.
- This classification is easily workable in practicals and most of the herbaria of the world are arranged according to this system of classification.
- The important merit of this classification is that every material was studied by them as a new material. Further complete description of each plant has been given.

Demerits :

1. Placed gymnosperms in between two groups (dicotyledons and monocotyledons) of angiosperms.
2. Dicotyledons have been divided into classes, series and orders, but monocotyledons have been directly divided into series.
3. In polypetalae, plants with superior ovary are treated first and with inferior ovary last whereas in gamopetalae, plants with inferior ovary have been treated first.
4. Family Cucurbitaceae (order Passiflorales) is mostly having gamopetalous condition, but has been placed in polypetalae.

3. Phylogenetic system of classification

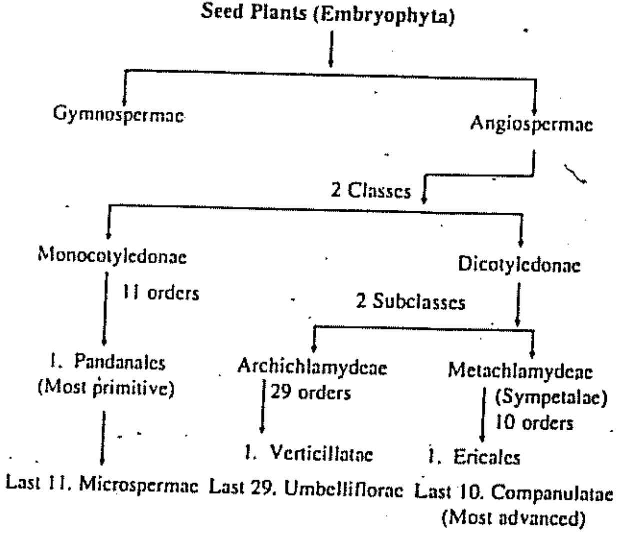
Phylogenetic system is that in which phylogenetic or evolutionary tendencies are taken into consideration for classification of plants or classification is given on the basis of evolution.

- The era of phylogenetic classification came into existence after publication of 'Origin of Species' by Charles Darwin (1859).
- The widely known classifications of this era are those of Eichler, Engler and Prantl, Rendle, Bessey, John Hutchinson and two modern, *i.e.*, of Takhtajan and Cronquist.

Classification of Engler and Prantl

Adolph Engler (1844–1930) and **Karl Prantl** (1849–1893) were **German botanists**. Engler was professor of botany in Berlin university and after his retirement, he held the post of director of **Berlin Botanical Gardens** for 32 years. **Prantl** was his associate in the garden.

- **Engler** and **Prantl** gave their phylogenetic classification in 23-volumes of Die naturlichen Pflanzen familien (1887–99).
- In this classification, they gave 280 families of Angiosperms.
- They considered **polyphyletic origin** (*i.e.*, along many lines) of angiosperms from a hypothetical gymnospermous ancestor.
- They considered monocots to be primitive than dicots and in dicots, apetalous (naked) flowers arranged in catkins (*i.e.*, amentiferae group) are considered to be primitive.
- They separated gymnosperms from angiosperms and united polypetalae and monochlamydeae into a single group, *i.e.*, archichlamydeae.
- **Pandanales is the most primitive and companulatae is the most advanced order.**
- Brief outline of this classification is as follows:



C.E. Bessey's classification

C. E. Bessey, an American botanist gave his phylogenetic system of classification in 1915 under the title **'The Phylogenetic Taxonomy of Flowering Plants'**. He gave his classification on the basis of some **guiding principles** (dicta) concerned with primitive and advanced characters in plants. His classification resembles with Bentham's and Hooker's classification.

- ○ According to Bessey, flowering plants originated from **Bennettitales** strobiliferous Cycads.
- ○ He called Angiosperms as **Anthophyta** and divided them into two groups—

Oppositifoliae (Dicotyledons) and **Alternifoliae** (Monocotyledons). Further Ranales was considered to be most primitive order of Angiosperms, which gave rise to other groups.

Hutchinson's classification

John Hutchinson (1884–1972) was an English botanist and he was director of Royal Botanical Garden, Kew, England.

- He gave his phylogenetic system of classification in his two volumes of **'Families of Flowering Plants'** (1st volume in 1926 and 2nd volume in 1934).
- His classification is more closely related to that of Bentham and Hooker than Engler and Prantl.

classification

..logenetic

- This classification was revised by him in **'British Flowering Plants'** in 1959.
- His classification is given on the basis of 24 principles called **Principles of Phylogenetic classification.**
- 411 families of angiosperms have been given by Hutchinson.

Hutchinson's 24 principles of phylogenetic classification are:

1. Evolution is both **upwards and downwards.** The former leads to **preservation** and later leads to **suppression.**
2. Evolution does not involve all the organs at the same time.
3. Trees and shrubs are primitive than herbs.
4. Trees and shrubs are primitive than climbers.
5. Normal habit is primitive than parasitic or saprophytic habit.
6. Terrestrial habit is primitive than aquatic habit.
7. Perennials are primitive than biennials and annuals.
8. Dicots are primitive than monocots.
9. Spiral arrangement of organs is primitive than cyclic arrangement.
10. Simple leaf is primitive than compound leaf.
11. Bisexual flower is primitive than unisexual flower.
12. Solitary flower is primitive than inflorescense.
13. Monoecious condition is primitive than dioecious condition.
14. **Hypogyny** is primitive than **perigyny and epigyny.**
15. Actinomorphic flowers are primitive than zygomorphic flowers.
16. **Petaliferous** condition is primitive than apetalous (naked) condition.
17. Aestivation type **imbricate** is primitive than **valvate.**
18. **Polypetalous** condition is primitive than **gamopetalous condition.**
19. **Apocarpy** (free carpels) is primitive than **syncarpy** (fused carpels).
20. Free anthers are primitive than fused anthers (Syngenesious condition).
21. **Polycarpy** (Many carpels) is primitive than **oligocarpy** (few carpels).
22. Many stamens condition is primitive than few stamens.
23. Endospermic seeds with small embryo are primitive than non-endospermic seeds and large embryo.
24. Single fruit is primitive than aggregate fruit.

- Hutchinson believes in **monophyletic origin** of angiosperms.
- **Magnoliaceae** and **Ranunculaceae** are most primitive families and **Gramineae** (Poaceae) is most advanced family according to Hutchinson.
- Some modern phylogenetic systems of classification have also been given, *e.g.*,

(a) By **Takhtajan** (Russian) in 1980. He called Angiosperms as **Magnoliophyta.**

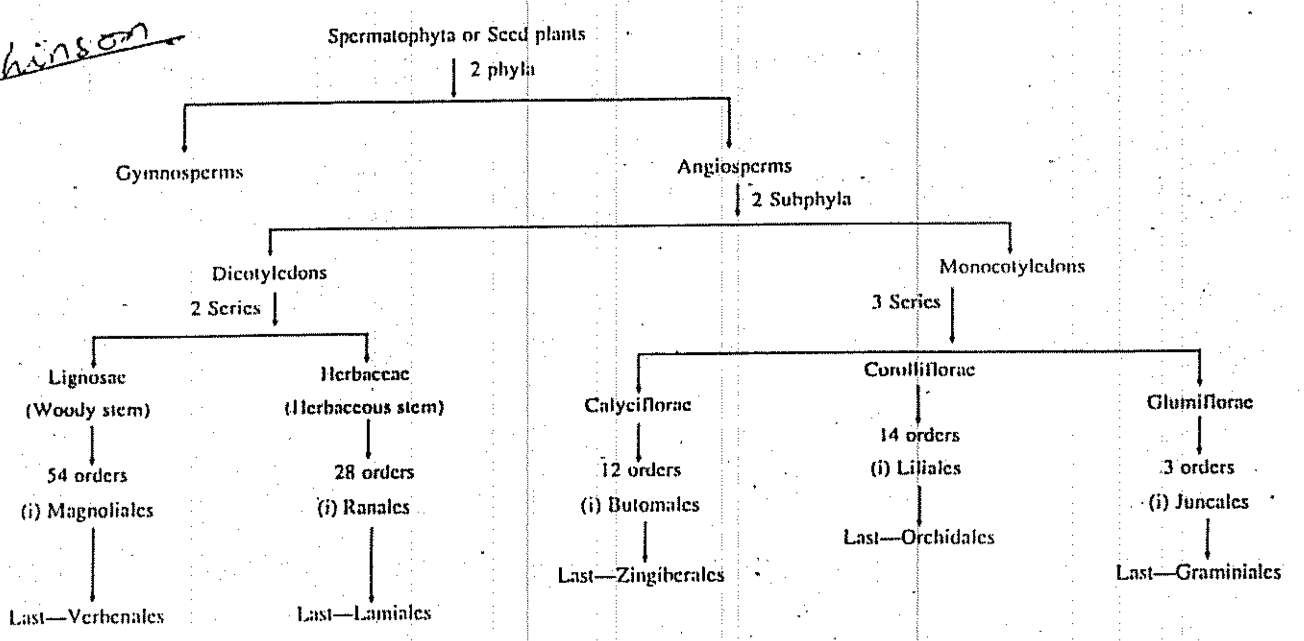
- According to Takhtajan, "Taxonomy without phylogeny may be likened to bones without flesh".

(b) By **Cronquist** (American) in 1981. He called flowering plants (Angiosperms) as **Magnoliophyta.**

(c) By **Thorne** (American) in 1981. He used the term **Annonopsida** for Angiosperms.

- Outline of this classification is given below:

Hutchinson


Spermatophyta or Seed plants
2 phyla
Gymnosperms
Angiosperms
2 Subphyla
Dicotyledons
Monocotyledons
2 Series
3 Series
Lignosae
(Woody stem)
Herbaceae
(Herbaceous stem)
Calyciflorae
Corolliflorae
Glumiflorae
54 orders
(i) Magnoliales
Last—Verbenales
28 orders
(i) Ranales
Last—Lamiales
12 orders
(i) Butomales
Last—Zingiberales
14 orders
(i) Liliales
Last—Orchidales
3 orders
(i) Juncales
Last—Graminiales

HERBARIUM

Collection of plants or plant parts, which are dried, pressed, mounted on herbarium sheets and which have been identified and classified according to a definite system of classification so that they provide maximum information about the plants concerned, is called **Herbarium.**

- Succulents are not mounted on herbarium sheets but are collected in 4% formalin or FAA (formalin acetic acid).
- Specimen should possess all parts including root system, flowers and young fruits.
- Herbarium making art was started by Caesalpini *et al.* (1550).
- Greatest herbarium of world is herbarium of Royal Botanical Garden, Kew, England, which is having 6,00,0000 specimens (6 millions specimens).
- In India, important herbaria are as follows:

1. **Biggest herbarium of India is herbarium of Indian Botanical Garden, Kolkata, having 1 million specimens** (10 lakh).
2. Herbarium of F.R.I. Dehradun—having 3 lakh specimens.
3. Herbarium of Agricultural College and Research Institute Coimbatore-having about 2 lakh specimens.
4. Herbarium of National Botanical Garden (NBRI), Lucknow—having 40,000 specimens.

- **Size of herbarium sheet–Standard,** *i.e.*, $16\frac{1}{2} \times 11\frac{1}{2}$ inches or 41·25 × 28·75 cms.

BOTANICAL GARDENS

Botanical garden is actually a collection of living plants for both pure and applied studies.

- Largest botanical garden of world is:

Royal Botanical Garden, Kew, England : This was started as a private garden of **Henery Capel.** Actual history of this garden started in 1759 when **William Aiton** was appointed its first superintendent. In 1841, this was transferred from crown to state. This garden started from **20** acres and now it occupies **300 acres** of land.

- Largest botanical garden of India is– **Indian Botanical Garden, Kolkata.** This was also started with economic reasons, but now it is concerned with scientific studies. Efforts of **William Roxburgh** (father of Indian Botany) made this garden world famous. **George King** was the designer of this garden.

○ **Great Banyan Tree :** It is the characteristic feature of Indian botanical garden. This tree is one of the largest living plants in the world and is 200 years old. Walk around the tree makes about a **quarter of mile.** It is 100 ft. high and is still growing. Canopy of this tree covers 4 acres of land.

BOTANICAL SURVEY OF INDIA (BSI)

BSI started its working in 1890 and has its headquarters at Howrah (Kolkata). The function of BSI is plant exploration and preparation of regional floras as well as flora of India.

IMPORTANT TAXONOMIC TERMS

Here, we are presenting some of the fundamental taxonomic terms, which are used in description of different plants.

1. **Habitat :** The place of occurrence of a plant is called its habitat.

2. **Habit :** Characteristic bodily appearance of plant.

3. **Herb :** Any plant with non-woody stem (without lignin) without persistent aerial parts.

4. **Shrub :** A plant of limited growth having woody stem and branching near the ground.

5. **Tree :** A woody plant having a distinct trunk and branching at a height from the ground.

6. **Root :** A descending axis, without nodes and growing opposite the stem.

(a) **Tap root :** Root arising from the radicle of embryo and bearing smaller lateral branches.

(b) **Adventitious root :** Roots arising from any other part other than radicle.

7. **Stem :** Main axis of a plant, which is having leaves and buds at its nodes.

8. **Culm :** A stem of jointed nature, which is having solid nodes and hollow internodes, *e.g.*, bamboo, wheat (gramineae) and sedges (cypraceae).

9. **Fistular stem :** A stem with hollow interior is called fistular stem, *e.g.*, in wheat.

10. **Leaf :** Lateral outgrowth on stem at a node, having a bud in its axil.

(a) **Cauline leaves :** Leaves present on main stem only, *e.g.*, in palms.

(b) **Ramal leaves :** Leaves present on lateral branches, *e.g.*, in mango.

(c) **Radical leaves :** The leaves arising from a reduced underground stem, *e.g.*, in onion.

11. **Petiole :** Stalk of leaf is called petiole.

12. **Stipule :** A pair of appendages present at the point where leaf is attached to the stem.

(a) **Intrapetiolar stipules :** Stipules between leaf petiole and axis.

(b) **Interpetiolar stipules :** Stipules present between petioles of opposite or whorled leaves, *e.g.*, in family Rubiaceae.

(c) **Ochreate stipules :** Stipules forming a hollow tube around the stem from the node upto certain height, *e.g.*, in *Polygonum.*

(d) **Foliaceous stipules :** Stipules modified into leaf like structures, *e.g.*, in *Lathyrus* and *Pisum.*

(e) **Spinous stipules :** Stipules modified into spiny structures, *e.g.*, *Acacia* and *Zizyphus*.

(f) **Tendrillar stipules :** Stipules modified into tendrillar structures, *e.g.*, in *Smilax*.

13. **Stipels :** Stipule like structures at the base of leaflets of compound leaf, *e.g.*, in members of family Papilionaceae.

14. **Phyllotaxy :** Arrangement of leaves on stem is called phyllotaxy.

(a) **Alternate or Spiral phyllotaxy :** Single leaf at each node.

(i) **1/2 or 2-ranked alternate phyllotaxy :** 3rd leaf standing over first, *e.g.*, in Gramineae (Poaceae) or grasses.

(ii) **1/3 or 3-ranked alternate phyllotaxy :** 4th leaf standing over the first and one spiral is present between them, *e.g.*, in *Cyperus*.

(iii) **2/5 or 5-ranked :** 6th leaf standing over the first and two spirals between them, *e.g.*, in China rose (*Hibiscus rosa-sinensis*).

(iv) **3/8 or 8-ranked :** 9th leaf standing over the first and 3-spirals are present between them, *e.g.*, in papaya.

o 2/5 or 5-ranked phyllotaxy is the most common type of alternate phyllotaxy.

(b) **Opposite phyllotaxy :** A pair of leaves at each node.

(i) **Opposite decussate :** A pair of leaves at right angles to next upper or lower pair.

(ii) **Opposite superposed :** A pair of leaves directly over the pair below it.

(c) **Whorled phyllotaxy :** More than two leaves at each node constitute whorled phyllotaxy.

15. **Simple leaf :** A leaf having a single blade.

16. **Compound leaf :** A leaf having many segments or leaflets.

(a) **Pinnately compound :** Feather like compound leaf, having leaflets arranged in two rows on the **rachis**. (Axis of pinnately compound leaf is called **rachis**).

(i) **Paripinnate :** Having even number of leaflets.

(ii) **Imparipinnate :** Having odd number of leaflets, *i.e.*, a single leaflet at the tip.

(b) **Palmately compound :** Palm-like compound leaf, *i.e.*, having leaflets, arising from a common base (like fingers from palm).

INFLORESCENCE

1. Inflorescence

Cluster of flowers or arrangement of flowers on floral axis.

2. Peduncle

Stalk having inflorescence is called peduncle.

3. Scape

A leafless peduncle produced by underground stem bearing no foliage leaves (but bearing scales or bracts), which may be having a single flower or many flowers, *e.g.*, in **onion, garlic, gladiolus, canna**, etc.

4. Racemose inflorescence

An inflorescence of **indefinite or indeterminate growth** having lateral or axillary flowers borne acropetally (oldest at base and youngest at apex). Different types of racemose inflorescence are as follows:

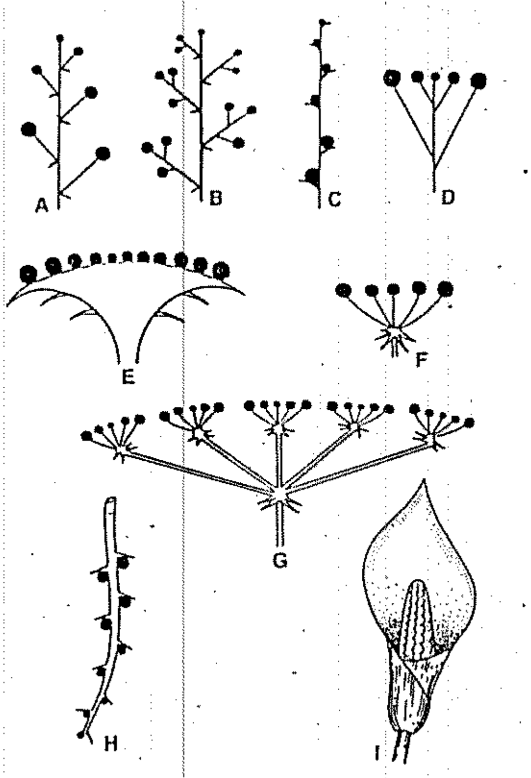


Fig. 19.1. Types of racemose inflorescence A. Raceme B. Panicle C. Spike D. Corymb E. Head or capitulum F. Simple umbel G. Compound umbel H. Catkin or ament I. Spadix.

(a) **Raceme :** Type of racemose in which **pedicillate** (*i.e.*, with stalks) flowers are borne acropetally, *e.g.*, radish, *Delphinium*, etc.

(b) **Panicle :** Branched raceme is called **panicle.**

(c) **Spike :** Type of racemose in which sessile (*i.e.*, without stalk) flowers are borne acropetally, *e.g.*, *Adhatoda.*

(d) **Spikelet :** Unit of compound inflorescence of grasses (members of family Poaceae) *i.e.*, **a secondary spike.**

(e) **Ament or Catkin :** A type of racemose in which unisexual, apetalous, deciduous and usually bracteate flowers are borne acropetally or **a spike of unisexual flowers.**

(f) **Spadix :** A **fleshy spike covered with spathe** is called spadix, *e.g.*, maize, banana, etc.

(g) **Corymb :** A type of raceme in which pedicels are of unequal length and reach upto almost same height. This is more or less flat topped inflorescence and outer flowers open first, *e.g.*, in candytuft (*Iberis amara*).

(h) Capitulum or Head : It is flat topped or spherical, dense racemose inflorescence, in which many sessile flowers are borne on a common receptacle in acropetal succession, *i.e.*, outer flowers are more mature, *e.g.*, in Compositae or Asteraceae family.

(i) Umbel : Type of racemose in which several pedicillate flowers arise from a common point. Again outer flowers are more mature, *e.g.*, in coriander, *Foeniculum*, etc. (Family – Apiaceae or Umbelliferae).

5. Cymose Inflorescence

A more or less flat topped, broad inflorescence of determinate growth or definite growth, where central flower opens first (*i.e.*, central flower is most mature). Here the main axis terminates in a flower.

Main types of cymose inflorescence are:

(a) Uniparous or Monochasial cyme : The main axis ends into a flower and producing only one lateral branch at a time ending in a flower or a cyme reduced to a single flower on each axis.

(i) Scorpioid monochasial : Here lateral flowers are borne alternately on opposite sides of pseudo-axis.

(ii) Helicoid cyme or Bostryx : Here lateral branches arise from the same side.

(b) Biparous or Dichasial cyme : Here two flowers arise from the same point (time) and again central flower is most mature or cyme with two lateral shoots or branches arising from the primary axis below the flower, *e.g.*, *Ixora*, *Mussaenda*, etc.

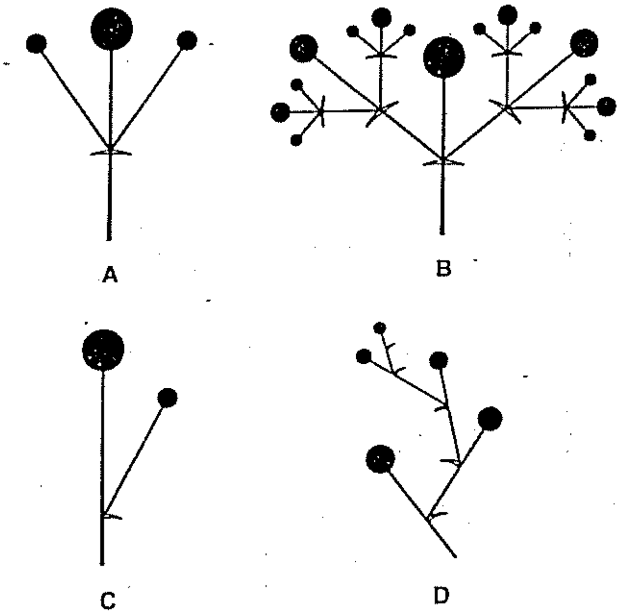


Fig. 19.2. Types of cymose inflorescence A. Simple dichasial cyme B. Compound dichasial cyme C. Simple monochasial cyme D. Helicoid cyme (bostryx)

Some special types of inflorescence:

6. Cyathium

It is characteristic inflorescence of *Euphorbia*, in which single female flower is present in the centre and number of male flowers around it, inside a cup-shaped involucre (whorl of bracts).

7. Hypanthodium

It is characteristic inflorescence of *Ficus* (Family Moraceae), *i.e.*, fig, peepal, etc. Here a cup-shaped cavity with an apical opening or ostiole is formed by a fleshy receptacle, which is guarded by inwardly projecting hairs and bear flowers on the inner wall of the cavity, *i.e.*, female (♀) flowers at the base and male (♂) flowers above.

8. Verticillaster

It is characteristic inflorescence of *Ocimum* (Tulsi) of family Lamiaceae or Labiatae. Here flowers are arranged in two opposite cymose groups on each node.

9. Cincinnus

It is characteristic of family Caryophyllaceae. Here dichasial cyme is present in lower part and monochasial cyme in upper parts.

10. Tassel

Staminal or male inflorescence in maize (*Zea mays*). Here male flowers are present in terminal panicle called tassel.

FLOWER

1. Flower

It is a modified shoot with highly condensed internodes and leaves are modified variously to perform different functions (calyx, corolla, androecium and gynaecium).

2. Pedicel

Stalk of flower is called pedicel.

3. Receptacle or Torus

More or less enlarged or elongated end of the flower axis on which different floral parts are borne.

4. Bract

Bract is a modified leaf, in the axil of which a flower arises.

5. Bracteole

A secondary bract or bractlet.

6. Spathe

A single, large and showy bract, which encloses or covers an inflorescence, *e.g.*, spike covered with spathe is spadix as in maize, banana, etc.

7. Involucre

A whorl of bracts surrounding an inflorescence is called involucre.

8. Epicalyx

A set or whorl of bracts (bracteoles) adjacent to and resembling the calyx is called **epicalyx,** *e.g.,* in Malvaceae family (*Hibiscus rosa-sinensis*).

9. Sessile

Flower without pedicel is sessile flower.

10. Pedicillate

Flower with pedicel is pedicillate.

11. Complete

A flower with all the 4 whorls of floral parts, *i.e.,* calyx, corolla, androecium and gynaecium.

12. Incomplete

A flower lacking any of these 4 whorls of floral parts is incomplete, *e.g., Euphorbia.*

13. Actinomorphic or Regular

A flower which can be divided into two equal halves in **any plane** or in more than one plane.

14. Zygomorphic or Irregular

A flower, which can be divided into two equal halves in **only one plane,** *e.g.,* pea, *Salvia, Delphinium,* etc.

15. Bisexual or Hermaphrodite

A flower having both male and female parts in it (*i.e.,* androecium and gynaecium).

16. Unisexual

A flower having either **male part** or **female part** is unisexual.

- A unisexual flower may be **staminate** (♂) or **pistillate** (♀).

17. Neutral or Neuter

A sterile flower having only perianth (calyx and corolla), without androecium and gynaecium (*i.e.,* necessary whorls).

18. Monoecious

When both types of unisexual flowers (staminate and pistillate) are present on the same plant, this condition is monoecious.

19. Dioecious

When male and female flowers are present on different plants.

20. Polygamous

When unisexual as well as bisexual flowers are present on the same plant, this condition is polygamous.

○ (Monoecious, dioecious and polygamous conditions are of plant).

21. Dimerous

When floral parts are in 2's or multiples of 2, *e.g.,* **poppy** flowers.

22. Trimerous

When floral parts are in 3's or multiples of 3, *e.g.,* **monocot** flowers (Liliaceae).

23. Tetramerous

When floral parts are in 4's or multiples of 4, *e.g.,* **mustard.**

24. Pentamerous

When floral parts are in 5's or multiples of 5, *e.g., Solanum.*

25. Hypogynous

A flower in which all other floral parts arise from the base of the ovary (or ovary is at top), is called hypogynous flower. Ovary is here said to be **superior.**

26. Perigynous

A flower in which other floral parts arise from **around** the ovary, is perigynous, *e.g.,* peach, plum, etc. Here ovary is **half inferior** or **half superior.**

27. Epigynous

A flower in which other floral parts arise from **the top of** the ovary, is epigynous, *e.g.,* Cucurbitaceae.

○ Here the ovary is **inferior.**

28. Florets

Individual flowers as in **Compositae** and **Gramineae.**

29. Hypanthium

Tubular or flask-shaped zone of the floral axis, which bears floral leaves on its margins.

CALYX

1. Calyx

It is the outermost whorl of the flower parts and its unit is **sepal.**

2. Sepal

Unit of calyx is called sepal.

3. Polysepalous

Where **free or separate** sepals are present in calyx.

4. Gamosepalous

Where sepals are **united.**

5. Pappus

When sepals (calyx) are reduced to persistent tuft of fine hairs, is called pappus, *e.g.,* in family **Compositae** (Asteraceae).

This pappus is attached to fruits and help in the dispersal of fruits.

6. Caducous or Fugacious

Which fall-off very early, *e.g.*, in poppy.

7. Deciduous

Which fall-off just after fertilization, *e.g.*, in mustard.

8. Persistent Calyx

Which does not fall-off and remain attached even to fruits. *e.g.*, Solanaceae (*Solanum*, *Datura*, etc.).

9. Accrescent Calyx

Persistent calyx growing in size along with fruit, *e.g.*, in *Physalis*.

10. Calyculus

Structure resembling calyx, composed of bracts and bractlets.

COROLLA

1. Corolla

It is second whorl of flower, made of petals.

2. Petal

Unit of corolla and is generally coloured and showy.

3. Polypetalous

Free petals.

Gamopetalous : United petals.

4. Perianth

It is collective term for **calyx and corolla** (when calyx and corolla not distinguished).

5. Tepal

Unit of perianth or individual member of perianth.

6. Achlamydeous

Without perianth or naked.

7. Lodicule

Minute perianth parts of a grass flower.

8. Aestivation

Arrangement of floral parts during bud-condition.

Some common types of aestivation are :

(a) **Valvate :** Sepals or petals meeting by their edges without any overlapping, *e.g.*, *Solanum*.

(i) **Induplicate valvate :** Margins of each part folded inwards, *e.g.*, *Ipomoea*.

(ii) **Reduplicate valvate :** Margins of each part projecting outward.

(b) **Twisted or Contorted or Convolute :** In this type of aestivation, one margin of each part is **exterior** and the other **interior.**

(c) **Imbricate (1, 1, 3) :** It is aestivation of five parts, where one is **exterior,** one is **interior** and rest three are **having one margin exterior and other interior.** (1 exterior, 1 interior, 3 exterior-interior, *i.e.*, 1, 1, 3).

- **Descending imbricate or Vexillary :** It is characteristic aestivation of corolla of pea (Papilionaceae) where posterior petal is outermost.

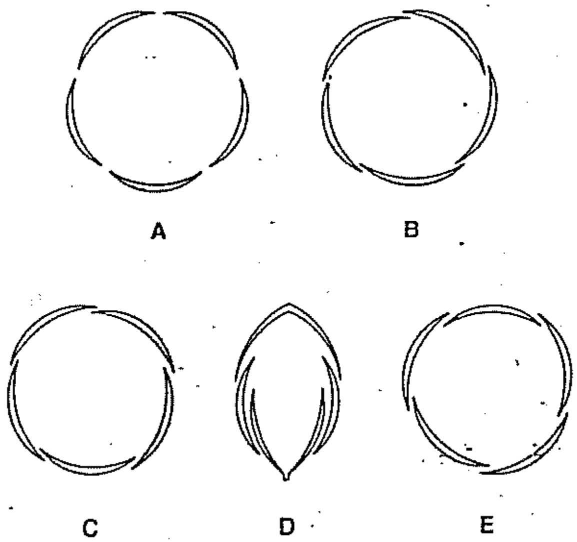


Fig. 19.3. Aestivation types A. Valvate B. Twisted C. Imbricate D. Vexillary or descending imbricate E. Quincuntial

- **Ascending imbricate :** Characteristic of corolla of family Caesalpiniaceae (*Cassia*), where posterior petal is **innermost.**

(d) **Quincuncial (2, 2, 1) :** It is aestivation of 5 parts, where **two are exterior, two interior and the fifth is having one margin exterior and the other interior.**

Shapes of corolla

9. Cruciform or Cross shaped

This is characteristic of family Cruciferae or Brassicaceae. Here there are 4 petals, which are arranged in the form of a cross (×) or diagonally placed. Further each petal is differentiated into a claw and limb.

- o (The name **Cruciferae** of the family is on the basis of **cruciform corolla).**

10. Companulate

Bell shaped corolla, *e.g.*, in *Cucurbita*.

11. Infundibulum

Funnel shaped, *e.g.*, *Petunia* and *Ipomoea*.

12. Tubular

Gamopetalous corolla, which is tube like, *e.g.*, sunflower.

13. Papilionaceous or Butterfly shaped

This is characteristic of family **Papilionaceae.** Here there are 5 petals. Out of them, one **posterior** is large called **standard or vexillum,** two lateral are called **wings** or **alae** and two innermost anterior small fused petals called **keel** or **carina.**

14. Bilabiate or Bilipped

Two lipped corolla, characteristic of family **Labiatae (Lamiaceae)**, *e.g., Ocimum.*

15. Ligulate or Strap shaped or Tongue shaped

Which is narrow below and flattened above like a strap.

Appendages of corolla

16. Corona

Any appendage present on corolla or in between stamens and corolla is called **corona** or **coronary structure,** *e.g.,* in *Calotropis* (Madar).

17. Spur

A tubular projection from calyx or corolla, *e.g.,* in *Delphinium* (Larkspur).

Arrangement of Floral organs or Parts

18. Anthophore

Internodal elongation between calyx and corolla is called anthophore, *e.g.,* in *Silene saxifraga.*

19. Androphore

Internodal elongation between corolla and androecium is called androphore, *e.g.,* in *Cleome* and *Cruetiva* (fam. Capparidaceae).

20. Gynophore

Internodal elongation between androecium and gynaecium is called gynophore, *e.g.,* in every plant of fam. Capparidaceae.

21. Androgynophore

When androphore and gynophore are present simultaneously, it is called androgynophore, *e.g.,* in *Cleome gynandra* Syn. *Gynandropsis gynandra* (fam. Capparidaceae).

ANDROECIUM

1. Androecium

It is male reproductive part of the flower and its unit is **stamen.**

2. Stamen

Unit of androecium or pollen producing organ of the flower. Stamen is having–anther, filament and connective.

3. Staminode

A reduced or sterile stamen is called staminode.

4. Polyandrous

Stamens free (*i.e.,* both filaments and anthers of different stamens are free), *e.g., Ranunculus.*

5. Monoadelphous

Filaments of stamens are united in one group, *e.g.,* **China rose** (fam. Malvaceae).

6. Diadelphous

Filaments of stamens are united in two groups or bundles, *e.g.,* in fam. Papilionaceae, *i.e.,* (9) + 1.

7. Polyadelphous

Filaments of stamens are united in several groups, *e.g.,* in *Citrus.*

8. Syngenesious

When stamens are united by their anthers (filaments free), it is called syngenesious condition, *e.g.,* in fam. **Compositae** (Asteraceae).

9. Synandrous

Stamens are united throughout their length, *i.e.,* both by filaments and anthers, *e.g.,* in *Cucurbita.*

10. Epipetalous

Condition in which stamens are attached to corolla or petals, *e.g., Solanum.*

11. Gynandrous

Stamens united with carpels either throughout the length or by their anthers only, *e.g., Calotropis.*

12. Diplostemonous

Here stamens are in two whorls and those of the outer whorl are alternate with the petals.

13. Obdiplostemonous

Here stamens are in two alternating whorls and those of the outer whorl are opposite the petals (not alternate), *e.g.,* in *Murayya* (fam. Rutaceae) and *Stellaria* (fam. Caryophyllaceae).

14. Didynamous

There are four stamens, 2 are long and 2 are short, *i.e.,* 2 + 2, *e.g.,* in *Ocimum* (fam. Labiatae).

15. Tetradynamous

There are six stamens, 4 are long and 2 are short, *i.e.,* 4 + 2, *e.g.,* in *Brassica.*

16. Dithecous anther

A two celled or lobed anther, having 4 microsporangia or pollen chambers.

17. Monothecous anther

A one celled or lobed anther, having only 2 microsporangia or pollen chambers, *e.g.,* in **Malvaceae family.**

18. Extrorse anther

Anther dehiscing towards periphery of flower, *e.g.,* in fam. **Malvaceae, Ranunculaceae,** etc.

19. Introrse anther

Anther dehiscing towards the centre of the flower. In most of the families, this type of anthers are present.

20. Adnate anther

Filament attaching or running complete length of the anther, *i.e.*, from base to apex.

21. Sagittate anther

Anther like an arrow, *e.g.*, in family Apocyanaceae (*Nerium*).

22. Versatile anthers

These are characteristic of grasses (fam. Poaceae or Gramineae). Here filament is attached to back of the anther at a point, so it can swing freely.

GYNAECIUM OR PISTIL

1. Gynaecium

It is the female reproductive part of the flower and its unit is **carpel**.

2. Carpel

Unit of gynaecium or pistil. A carpel is having –stigma, style and ovary.

3. Pistillode

A sterile pistil or gynaecium.

4. Monocarpellary, bicarpellary, tricarpellary, tetracarpellary, pentacarpellary, polycarpellary or multicarpellary

Pistil or gynaecium having 1, 2, 3, 4, 5 and numerous carpels respectively.

5. Apocarpous

Pistil or gynaecium with separate or free carpels, *e.g.*, in *Ranunculus*.

6. Syncarpous

Pistil with united or fused carpels.

7. Position of ovary

(a) **Superior :** When condition in flower is hypogynous, then ovary is superior, *e.g.*, in *Citrus, Solanum*, etc.

(b) **Semi-inferior :** When condition in flower is perigynous, then ovary is semi-inferior, *e.g.*, peach, plum, rose, etc.

(c) **Inferior :** When condition in flower is epigynous, then ovary is inferior, *e.g.*, ***Cucurbita*, coriander.**

8. Locules

Chambers or compartments of ovary are called locules. On this basis, ovary may be **unilocular** (1 locule), **bilocular** (2 locules), **trilocular** (3 locules)..... **multilocular** (many locules).

9. Placenta

Part of the ovary, where ovules are borne or attached.

10. Placentation

Arrangement of ovules inside the ovary on placenta is called placentation. Main types of placentation are:

(a) **Axile :** Ovary bi, tri, tetra or multilocular and ovules are borne on central mound or axis, *e.g.*, in *Solanum, Citrus, Hibiscus*, etc.

(b) **Marginal :** Ovary unilocular and ovules are borne on margin, *e.g.*, in family **Leguminosae or Fabaceae.**

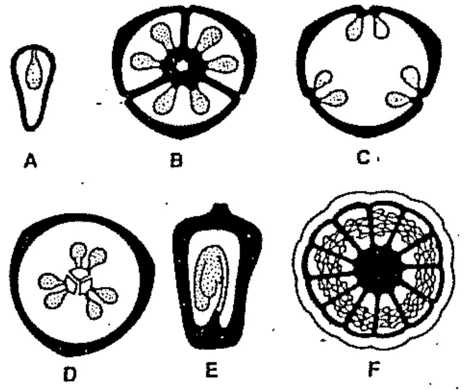


Fig. 19.4. Different types of placentation A. Marginal B. Axile C. Parietal D. Free central E. Basal F. Superficial

(c) **Parietal :** Ovary is unilocular and ovules are borne on periphery, *e.g.*, in *Brassica, Argemone*, etc.

(d) **Free central :** Ovary is unilocular and ovules are borne on central mound or axis, *i.e.*, (axile – septa), *e.g.*, in family **Caryophyllaceae** (*Stellaria*).

(e) **Basal :** Ovary is unilocular and ovules few or reduced to one and borne at the base of the ovary, *e.g.*, in **Compositae or Asteraceae.**

(f) **Superficial :** Ovary is multilocular and ovules are borne on inner surface or partition walls, *e.g.*, in water lily.

11. Gynobasic style

It is characteristic feature of family **Labiatae or Lamiaceae** (*Ocimum*). Here style arises from the depression or cavity in the centre of ovary or directly from thalamus.

12. Stylopodium

When base of the style is swollen to form a **pad like structure**, it is called stylopodium, *e.g.*, in family Umbelliferae or Apiaceae (Coriander).

13. Plumose stigma

Feather like stigma is called, plumose stigma, *e.g.*, in grasses.

14. Resupination

Turning or twisting of ovary or flower through 180°, *i.e.*, upside down. It is feature of most of the **orchids.**

Floral Formula (F.F.)

Shorthand notation of floral characters is called floral formula or it is a handy method of summarizing various characters of a flower by a type of short hand method, which reveals essential facts of the flower.

- Different shorthand notations or symbols used in floral formulae are:

Br. — Bracteate.
Ebr. — Ebracteate.
$\oplus$ — Actinomorphic or regular flower.
% or + or Φ — Zygomorphic or irregular flower.
(⚥) — Bisexual flower.
♀ — Female flower.
♂ — Male flower.
K — Calyx.
C — Corolla.
P — Perianth.
A — Androecium.
G — Gynaecium.
$\underline{G}$ — Superior ovary.
$\overline{G}$ — Inferior ovary.

1, 2, 3, 4, ...∞ → Number of sepals, petals, stamens or carpels.

( ) — Fused or united, *e.g.*, $C_{(5)}$, *i.e.*, five petals of corolla fused.
$\overset{\frown}{C\ A}$ — Epipetalous condition, *i.e.*, stamens attached to petals,

e.g., F.F. of *Solanum nigrum* (Solanaceae) is
Ebr. $\oplus$ ⚥ $K_{(5)}\ \overset{\frown}{C_{(5)}\ A_5}\ \underline{G_{(2)}}$

Floral Diagram (F.D.)

It is ground plan of a flower or cross-section of flower is represented by means of F.D. or by this method, many characteristics of floral parts and symmetry can be represented in a graphic form.

- In a F.D., the side towards mother axis is the **posterior** side of the flower and on lower side, *i.e.*, towards bract is the **anterior** side of the flower.

(Mother axis—The axis from which flower arises).

FAMILY–CRUCIFERAE OR BRASSICACEAE (MUSTARD FAMILY)

The plants of this family are cosmopolitan in distribution, although mostly in temperate or cold regions. Important plants of this family in India are–*Brassica*, *Raphanus*, *Iberis* (Candytuft), *Nasturtium*, etc.

Phanerogams
Dicotyledons
Polypetalae
Thalamiflorae
Parietales
Brassicaceae

Chief vegetative features

Plants are mostly annual or perennial herbs.

- A pungent watery juice is present in plants.
- Tap root which becomes fleshy due to storage of food materials.
- Presence of oil secreting glands containing **Myrosin** enzyme is the important anatomical feature.

Inflorescence

Generally corymb or Corymbose raceme. (raceme with pedicels of different length).

Flower

Generally ebracteate, pedicillate, bisexual or hermaphrodite, actinomorphic (rarely zygomorphic as in *Iberis*), hypogynous, tetramerous.

Calyx

4 Sepals– 2 + 2, *i.e.*, in two whorls of two each, **outer sepals are antero-posterior**, polysepalous.

Corolla

4 petals, polypetalous, **cruciform**, *i.e.*, arranged in cross (×) shaped manner, petals are clawed, sometimes petals may be replaced by stamens (as in *Capsella bursa-pastoris*).

Androecium

6 stamens, polyandrous, **tetradynamous** condition, *i.e.*, 4 + 2 or in two whorls, 4 inner long and 2 outer short, anthers–dithecous and introrse.

Gynaecium

Bicarpellary, syncarpous, ovary-superior, unilocular with parietal placentation. Two carpels are placed side by side or transversely. At maturity, ovary becomes bilocular due to formation of **false septum (replum)**, ovules many, style short, stigma–simple or bifid.

Fruit

Siliqua (Dry dehiscent fruit formed by bicarpellary syncarpous gynaecium with replum) or **silicula** (when siliqua is condensed) or rarely **lomentum** (*Raphanus*).

F.F. (Floral Formula)

Ebr. $\oplus$ ⚥ $K_{2+2}\ C_4\ A_{2+4}\ \underline{G_{(2)}}$

F.D. (Floral Diagram)

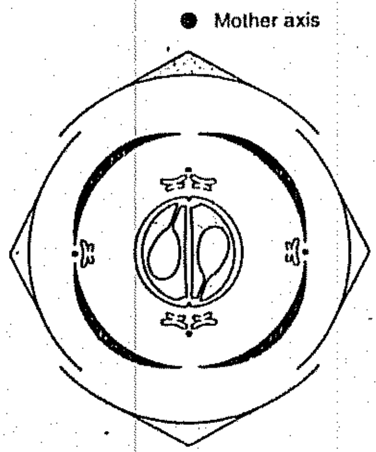


Fig. 19.5. Floral Diagram of *Brassica campestris* (Pili sarson)

Distinguishing features of the family

1. Oil secreting glands or cells in vegetative parts of the plants.
2. Inflorescence—corymb.
3. Cruciform (x-shaped) corolla-hence named 'Cruciferae'.
4. Tetradynamous condition of androecium.
5. Bicarpellary, syncarpous gynaecium with parietal placentation.
6. Presence of false septum or replum in ovary.
7. Fruit is siliqua.

Economic importance of family

The members of this family are sources of vegetables (food), oils, medicines, spices and some are ornamentals.

(I) Vegetables (Food)

1. *Brassica campestris* var. *sarson* (Pili Sarson) : Tender shoots are used as source of vegetable (Sarson Ka Saag).
2. *B. oleracea* var. *botrytis* (Cauliflower or Phool gobhi) : Underdeveloped inflorescence is used as source of vegetable.
3. *B. oleracea* var. *capitata* (Cabbage or Band gobhi)– Leafy buds are source of vegetable.
4. *B. oleracea* var. *caulorapa (gongylodes)*– (Knol-Khol or Ganth gobhi)– Thickened fleshy stem is source of vegetable.
5. *Brassica rapa* (Turnip or Shalgam) : Fleshy roots are eaten.
6. *Raphanus sativus* (Radish or Mooli) : Fleshy roots and pods are sources of vegetable.

(II) Oils

1. *Brassica campestris* : Seeds are source of Colza oil (Sarson Ka Tel).
2. *Brassica napus* or *B. campestris* var. *toria*– Seeds are source of **'Indian rape oil'** or **Tel toria.**
3. *Brassica juncea* (Indian mustard or Rye) : Seeds produce oil.
4. *Brassica alba* and *B. nigra* : (White mustard and Black mustard or Kali Rye).
5. *Eruca sativa* (Taramira) : Taramira oil is obtained from seeds, which is used as a cooking medium.

After extraction of oil from all these seeds, oil cake is left, which is nutritious cattle feed and is also used as fertilizer.

(III) Medicines and spices

1. *Rorippa montana* : It is stimulant and also a good appetizer.
2. *Lepidium sativum* : Liver troubles, asthama and piles are cured by tender shoots.
3. *Cherianthus cheiri* : Fever and bronchitis are cured by the seeds of this plant.
4. *Lobularia*– Used in gonorrhoea.
5. *Iberis amara*– In gout and rheumatism.
6. *B. alba, B. nigra* and *B. juncea* (rye)– Seeds are used as spices.

(IV) Ornamentals

1. *Iberis amara* (candytuft or chandni)– Winter herb grown for its white, beautiful flowers.
2. *Cherianthus cheiri* (wall flower).

FAMILY–MALVACEAE
(COTTON FAMILY OR MALLOW FAMILY)

The plants of this family are cosmopolitan in distribution, although more common in tropical (warm) regions.

- Important genera of this family are *Malva, Hibiscus, Gossypium, Sida*, etc.

Phanerogams
Dicotyldons
Polypetalae
Thalamiflorae
Malvales
Malvaceae

Chief vegetative features

Plants are mostly annual or perennial herbs or undershrubs, few are shrubs (*Hibiscus rosa-sinensis*) or China rose and rarely **trees** (*Kydia, Bombax*).

- Stem is generally covered with **stellate** (star-shaped branched) hair.
- Plant parts generally possess **mucilaginous sap.**

Inflorescence

Flowers are **solitary terminal** or **solitary axillary** or sometimes arranged in **raceme** or **cyme.**

Flower

Bracteate, **bracteolate** (bracteoles form a whorl outside calyx called **epicalyx,** which is protective in function), number of bracteoles is 3–∞ or absent in *Abutilon*, pedicillate, hermaphrodite or **bisexual**, actinomorphic, complete, hypogynous, pentamerous.

Calyx

5 Sepals, free or united at base, persistent, aestivation-valvate.

Corolla

5 petals, polypetalous, petals generally large and showy, aestivation-twisted or **imbricate.**

Androecium

Numerous (∞) stamens, monoadelphous and thus forming a staminal tube around ovary, epipetalous, anthers–**monothecous, reniform** (kidney-shaped), (Staminal tube fused with petals) and **extrorse.**

Gynaecium

2–∞ carpels, syncarpous, ovary superior, ovary- multilocular with axile placentation, one or more ovules in each locule, style long and stigmas equal to number of carpels.

Fruit

Generally capsule.

F.F. (Floral Formula)

$$\text{Br.} \oplus \text{⚥ Epi } K_{3-\infty}\ K_{5 \text{ or } (5)}\ \overset{\frown}{C_5\ A_{(\infty)}}\ \underline{G_{(2-\infty)}}.$$

F.D. (Floral Diagram)

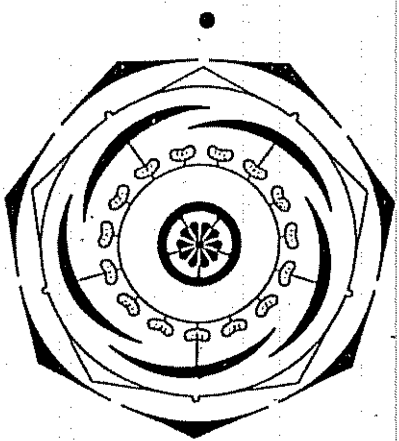


Fig. 19.6 Floral Diagram of *Hibiscus rosa-sinensis* (Gurhal)

Distinguishing features of family

1. Plant parts with mucilaginous sap and stem covered with stellate hairs.
2. Epicalyx (whorl of bracteoles) present.
3. Petals free (polypetalous).
4. Monoadelphous staminal tube, monothecous and extrorse anthers.
5. 2—∞ carpels, syncarpous with axile-placentation.

Economic Importance

The members of this family are sources of fibres, food, oils and some are ornamentals.

(I) Fibre yielding plants

1. *Gossypium arboreum, G. herbacium, G. hirsutum* (Cotton): Cotton fibres are long hairs from seed epidermis. This is also source of **cotton seed oil**, which is edible. **Oil cake** is an important cattle feed. **Oleomargarine** and **nitroglycerine** are other important products.
2. *Hibiscus canabinus* (Patsan or Deccanhemp): Cortical fibres from stem are used as jute substitute and are used in making ropes, canvas, floor mats, cardage, etc.
3. *Bombax malabaricum* Syn. B. ceiba (Semal or Kapok or Silk Cotton tree).
   - o Woolly fibres from pericarp of fruits are source of **Kapok** or **Semal** or **Silk cotton**.
4. *Abutilon theophrasti* (Indian Mallow or China jute): This takes good dye and is extensively grown in China.

(II) Food plants

1. *Abelmoschus esculentus* Syn. *Hibiscus esculentus* (Lady's finger or bhindi or Okra): Young fruits are used as favourite vegetable.

(III) Ornamental plants

1. *Althaea rosea* (Hollyhock or Gulekhera): Beautiful pink or red flowering plant.
2. *Hibiscus rosa-sinensis* (China rose or shoe-flower or gurhal): This is grown extensively as an ornamental plant with red or pink flowers.
3. *Malva sylvestris* (Mallow): An annual plant with purple rose flowers, is grown in gardens.

(IV) Others

1. *Abelmoschus moschatus* Syn. *Hibiscus moschatus* (musk mallow)
   Stems of this plant are used in clarifying sugar.
2. *Urena lobata*: Roots and bark are used as **cure for hydrophobia. Also** fibres obtained from it are used for making coffee sacks in Brazil.
3. *Kydia calycina*: Commonly called Pula provide timber used for toys, agricultural implements, etc.

FAMILY–LEGUMINOSAE OR FABACEAE (LEGUMES OR PULSES FAMILY)

This family is **third largest family** of angiosperms. The main characters of this family are: (i) Polypetalous condition. (ii) Single carpel (monocarpellary condition). (iii) Perigynous condition and marginal placentation.	Phanerogams Dicotyledons Polypetalae Calyciflorae Rosales Fabaceae

This family is divided into 3 sub-families:

1. **Papilionatae or Papilionoideae (Pea family):** It is characterized by **papilionaceous corolla** or butterfly shaped corolla (zygomorphic), descending imbricate aestivation of corolla and **diadelphous** condition of stamens.
2. **Caesalpinioideae (Cassia family):** It is characterized by zygomorphic flowers, ascending imbricate aestivation and 10 stamens (**diplostemonous condition** of stamens, *i.e.*, in 2 whorls of 5 each).
3. **Mimosoideae (Acacia or Kikar family):** It is characterized by actinomorphic or regular flowers, indefinite (∞) and exerted stamens.
   - o These 3 sub-families of Leguminosae thus can be distinguished on the basis of **corolla and androecium.**
   - o John Hutchinson raised these sub-families to the **rank of family**, *i.e.*, **Papilionaceae, Caesalpiniaceae** and **Mimosaceae.**

FAMILY—PAPILIONACEAE (PEA FAMILY)

This family is cosmopolitan in distribution. Important genera of this family are— *Pisum* (garden pea), *Cicer* (Gram), *Glycine* (Soybean), *Arachis* (Groundnut), *Dalbergia* (Shisham), etc.

Chief vegetative features

The plants of this family are herbs (*e.g.*, *Medicago*, *Trifolium*) or herbacious climbers (*e.g.*, *Pisum* and *Lathyrus*) or shrubs (*Cajanus*, *Crotolaria*) or trees (*Dalbergia*).

- Roots are having nodules which have *Rhizobium* bacteria, which help in nitrogen fixation.
- Leaves are simple or compound. In some cases, all the leaflets (*e.g.*, *Lathyrus*) and in some terminal leaflets (*e.g.*, *Pisum*) are modified into tendrils for climbing purpose.
- Foliaceous stipules (*i.e.*, stipules modified into leaf like structures) are present (*e.g.*, *Lathyrus*, *Pisum*), which are assimilatory in function.
- Sleep movements of leaves, *i.e.*, leaves having vertical position at night, are common in some plant species.

Inflorescence

Generally raceme, but variable in different members, *e.g.*, panicle in *Dalbergia* and solitary flowers in *Cicer*.

Flower

Bracteate, pedicillate, zygomorphic (irregular), bisexual, perigynous or hypogynous, pentamerous.

Calyx

5 sepals, more or less united, odd sepal is generally **anterior**, valvate or imbricate– aestivation.

Corolla

Papilionaceous or butterfly shaped corolla, *i.e.*, 5 petals are unequal in size. Posterior and outermost petal is largest and is called **standard or vexillum**, 2 lateral petals are similar and generally clawed called **wings or allae** and the two anterior petals are fused enclosing stamens and carpels called **keel or carina.**

Aestivation is **vexillary or descending imbricate.**

Androecium

10 stamens, **diadelphous condition**, *i.e.*, filaments of 9 stamens are united to form a tube and **one** (posterior) is free, *i.e.*, 1 + (9).

Anthers—Dithecous and introrse.

Gynaecium

Monocarpellary condition, *i.e.*, **single carpel**, ovary superior or partly inferior, **ovary-unilocular** with **marginal placentation.**

Fruit

Legume or pod.

F.F. (Floral Formula)

Br + ⚥ $K_{5\ \text{or}\ (5)}\ C_{1+2+(2)}\ A_{1+(9)}\ \underline{G_{1}}$

F.D. (Floral Diagram)

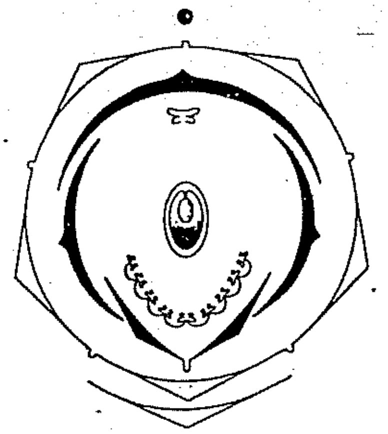


Fig. 19.7. Floral Diagram of *Pisum sativum* (Garden pea)

Distinguishing features of the family

1. Papilionaceous or butterfly shaped corolla.
2. Diadelphous condition of stamens.
3. Monocarpellary gynaecium with marginal placentation.
4. Legume or pod fruit.

Economic importance of family

The plants of this family are sources of pulses (food), fibre, timber, dyes and some are ornamentals.

(I) Sources of pulses (food)

Pulses we eat, are obtained from seeds of the members of this family, which are **rich source of proteins.**

(i) *Pisum sativum* (Garden pea or pea).
(ii) *Cicer arietinum* (Chick pea or Gram or Bengal gram).
(iii) *Cajanus cajan* (Pigeon pea or Red gram or Arhar).
(iv) *Vigna radiata* (Green gram or Moong).
(v) *V. mungo* (Black gram or Urd).
(vi) *V. sinensis* (Cow pea or Lobia).
(vii) *Lens culinaris* Syn. *L. esculenta* (Lentil or Masoor).
(viii) *Phoseolus vulgaris* (French bean)– Vegetable.
(ix) *P. aconitifolius* (Dal Moth).
(x) *Trigonella foenum-graecum* (Fenugreek or Methi).

- Leaves are used as source of vegetable. Seeds are used as spice.

(xi) *Glycine max* (Soybean)– Seeds are very rich in proteins (42%). **Soya milk** is also prepared from it.

(xii) *Arachis hypogea* (Groundnut or Peanut or Moongphali).

Seeds also provide peanut oil, which is used in preparation of vegetable ghee by hydrogenation.

(xiii) *Dolichos lablab* (Sem)– Vegetable.

(xiv) *Trifolium alexandrianum* (Clovers or Barseem)– Used as fodder.

(xv) *Lathyrus sativus* (Grass pea or Khesari dal)– Consumption of this dal causes lathyrism, which is associated with muscular distrophy, gross skeletal deformation and thinning of collagen fibres and fibrils. This results in lower limbs paralysis. Often this dal is adulterated with gram dal.

(II) Timber

Dalbergia sissoo (Shisham or Indian red wood) and *D. latifolia* (Kali shisham or Indian rose wood or Indian black wood).

(III) Ornamentals

(i) *Butea monosperma* (Palas or Dhak)– Deep red flowers and thus it is also called **'flame of the forest'**.

(ii) *Lathyrus odoratus* (Sweet pea or Wild pea)– Variously coloured flowers.

(IV) Other miscellaneous plants

(i) *Abrus precatorius* (Ratti or Crab's eye).

- Seeds of this plant are used by jewellers for weighing purpose. Each seed is having constant weight of 1.75 grains.
- Leaf juice is used for cure of **leucoderma** (skin disease).

(ii) *Crotolaria juncea* (Sun hemp)–Fibres from **phloem and pericycle of stem** (bast fibres) are obtained, used for making ropes, mats, etc.

- It is also important **'Green manure'** crop.

(iii) *Indigofera tinctoria* (Indigo or Neel):

Indigo dye used in dyeing and printing cotton, is obtained from this plant.

(iv) *Astragalus gummifer*–**'Gum tragacanth'**, which is commercially used as emulsifier, in cosmetics, in confectionary and in textile industry.

(v) *Desmodium gyrans* (Indian Telegraph plant)– This plant shows **spontaneous leaf movements.**

(vi) *Glycyrrhiza glabra* (Liquorice or Sweet wood or Mulathi)– Roots of this plant are used in sore-throat.

FAMILY—CAESALPINIACEAE (CASSIA FAMILY)

- The plants of this family are distributed in tropical (warm) areas.

Important plants of this family are– *Cassia* (Senna), *Bauhinia* (Kachnar), *Caesalpinia*, *Delonix* (Gulmohar), *Tamarindus* (Imli), etc.

Important vegetative features

Plants of this family may be **herbs** (*Cassia obtusifolia*) or **shrubs** or **trees** (*Bauhinia, Cassia fistula, Delonix*, etc.)

Inflorescence

Typical raceme. In *Cassia fistula*-pendulous raceme.

Flower

Bracteate, pedicillate, zygomorphic, bisexual, hypogynous or perigynous, pentamerous and showy.

Calyx

5 sepals, free or united, odd sepal is anterior, aestivation–imbricate or quincuntial type.

Corolla

5 petals, free, posterior petal is smaller and is innermost, aestivation– **ascending imbricate** type.

Androecium

10 stamens, polyandrous (free), sometimes stamens may be reduced to staminodes (*e.g.*, in *Cassia*).

Generally– **diplostemonous** condition, *i.e.*, stamens in 2 whorls of 5 each, anthers–dithecous and introrse.

Gynaecium

Monocarpellary condition (1 carpel), ovary– superior or slightly inferior, unilocular with marginal placentation. Style–generally sickle-shaped.

Fruit

Legume or pod.

F.F. (Floral Formula)

Br. + ⚥ $K_{5\text{ or }(5)}\ C_5\ A_{10\text{ or }5+5}\ \underline{G_1}$.

F.D. (Floral Diagram)

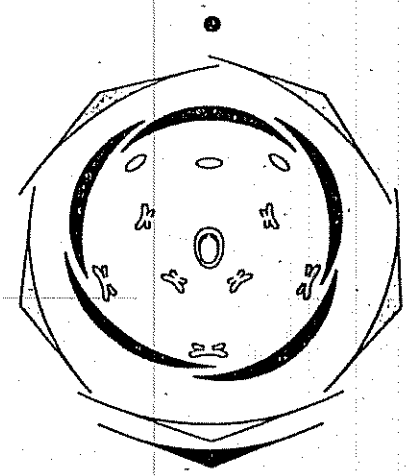


Fig. 19.8. Floral Diagram of *Cassia fistula* (Amaltas)

Economic importance of family

(I) Food plants

(i) *Bauhinia variegata* (Kachnar)– Flower buds are used as vegetable.

(ii) *Tamarindus indica* (Imli)– The fruits are used as condiment.

(II) Medicinal plants

(i) *Cassia fistula* (Senna or Amaltas)– The pulp of fruits as well as leaves are laxative and hence used in **'churns'**.

(ii) *Saraca indica* (Ashok)– One of the most sacred trees of India and its bark is used in troubles of manstruation.

(III) Ornamentals

(i) *Cassia fistula* (Amaltas)– Beautiful yellow flowers.

(ii) *Delonix regia* (Gulmohar)– Scarlet flowers.

(iii) *Saraca indica* (Ashok or Sita Ashok)– Orange flowers, used for decoration of temples.

(iv) *Parkinsonia aculeata* (Vilayati Kiker)– Fragrant yellow flowers are grown on road sides, railway platforms, etc. as ornamental plant.

(IV) Others

(i) *Caesalpinia sappan* (Sappan)– Heart wood of this provides a red orange dye, which is source of **'Gulal'** used in Holi festival.

(ii) *Haematoxylon campechianum* (Log wood)– A dye called **haematoxylin** is obtained from wood of this plant, which is used as a stain in anatomical preparations.

FAMILY–MIMOSACEAE (MIMOSA FAMILY OR KIKER FAMILY)

The plants of this family are distributed in tropical as well as sub-tropical regions of the world.

- Important plants of this family are *Acacia* (Babool or Kiker), *Mimosa* (Chui-mui), *Prosopis*, etc.

Chief vegetative features

The plants of this family are mainly trees or shrubs or undershrubs (xerophytic).

- Stem is generally covered with bark, often spiny.
- Stipules of leaves modified into spines.
- **Phyllodes** (leaf petioles modified into flattened leaf like structures) are present in some cases (*e.g., Acacia*).

Inflorescence

Globose or cymose head (*Acacia*), spike (racemose) in *Prosopis*.

Flower

Bracteate, pedicillate or sessile, actinomorphic (regular), bisexual, hypogynous or slightly perigynous, pentamerous.

Calyx

5 or 4 (*Mimosa*) sepals, free or fused, generally valvate aestivation.

Corolla

5 or 4 petals, polypetalous (free), valvate aestivation.

Androecium

Generally numerous (∞) stamens, polyandrous (only 4 in *Mimosa*), exerted (coming out of corolla tube). Anthers dithecous and introrse.

Gynaecium

Monocarpellary condition, ovary generally superior or slightly inferior, unilocular with marginal placentation, style–long and filiform, stigma-simple.

Fruit

A legume or **lomentum** (which is divided into many single seeded portions).

F.F. (Floral Formula)

$$\text{Br.} \oplus \text{⚥} \underset{(5 \text{ or } 4)}{\underset{\text{or}}{K_{5 \text{ or } 4}}} C_{5 \text{ or } 4} \underset{4}{\underset{\text{or}}{A_{\infty}}} \underline{G_1}.$$

F.D. (Floral Diagram)

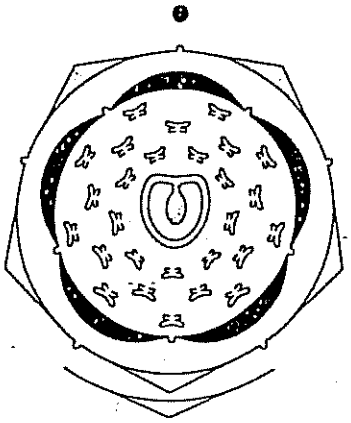


Fig. 19.9. Floral Diagram of *Acacia arabica* (Kiker)

Economic importance of family

Important plants of this family as well as their uses are;

1. *Acacia arabica* (Kiker or Babool)– **'Gum arabic'** is obtained from its bark. Also used for fuel purposes. Tannin is also obtained from its bark.

2. *Acacia catechu* (Khair or Kattha)– **'Kattha'** is obtained from its wood. Lac insects survive on this plant.

3. *Albizzia lebbek* (Siris)– Fuel wood is obtained. A special type of gum called **'Sresh'** is obtained from the bark.

4. *Prosopis juliflora* (Jhand or Algaroba)

○ An important soil binder plant in N.West India.

5. *Pithecolobium dulce* (Ingadulce or Jangal jalebi or Raintree)– Hedge plant. Juicy aril surrounding the seed is edible.

6. *Mimosa pudica* (touch me not or chui-mui)– Shows seismonastic movements. It is annual herb cultivated for purplish flowers.

7. *Leucaena leucophloea* (White popinae)– This tree is grown under social forestry nowadays.

FAMILY– CUCURBITACEAE (GOURD FAMILY)

The members of this family are generally found in tropical regions. Important plants of this family are: *Cucurbita, Cucumis* (cucumber), *Lagenaria, Luffa, Momordica, Coccinia*, etc.

Phanerogams
Dicotyledons
Polypetalae
Calyciflorae
Passiflorales
Cucurbitaceae

Chief vegetative features

The plants are mostly climbers or annual herbs.

- Stem is pentangular and hollow.
- Presence of leaf opposed, branched, spirally coiled tendrils is the characteristic feature of this family, which help in climbing.
- There is a controversy regarding the morphological nature of these tendrils, but the most accepted view is that these are combination of **modified branch** (base of tendrils) and **modified foliage leaves** (upper coiled portion).
- Presence of **bicollateral vascular bundles** in stem is the chief anatomical feature.
- Cucurbits (members of this family) are generally bitter and the bitter taste of cucurbits is due to alkaloid-cucurbitacin, *i.e.*, tetracyclic triterpenes.

Inflorescence

Flowers are generally solitary or arranged in racemes or cymes.

- The plants are usually **monoecious**, but sometimes **dioecious** (*Momordica* and *Coccinia*).

Flower

Usually ebracteate, actinomorphic, incomplete, unisexual, epigynous, pentamerous, yellow or white in colour.

Calyx

5 sepals, gamosepalous, aestivation-valvate or quincuntial.

Corolla

5 petals, generally gamopetalous (rarely polypetalous), aestivation-valvate or imbricate. Corolla is campanulate, rotate or salverform.

Androecium

Number of stamens is typically 5, but due to different degrees of cohesion, the condition is variable.

- Maximum variation from **polyandry** to **synandry** occurs in this family.
- 5, free stamens with monothecous anthers are present in *Fevillea* (simplest condition). In *Thladiantha*, there are five stamens with monothecous anthers (filaments of 4 stamens are united at base into 2 pairs and 5th stamen is free).
- In most of the members, there are 3 stamens, one with monothecous anther and two with dithecous anthers. Some workers consider this as **$2\frac{1}{2}$ stamen** condition (Probably by complete fusion of filaments and anthers of 2 pairs of stamens).

In *Cucurbita*, the stamens are spirally twisted and by fusion of connectives, anthers are also united (Synandrous condition).

- Anthers—**extrorse**.

(In female flowers, staminodes may be present).

Gynaecium

Tricarpellary, syncarpous, ovary-inferior, unilocular with parietal placentation, usually many ovules on each placenta, style-one and stigmas-three.

Fruit

Pepo.

F.F. (Floral Formula)

Male flower – $\oplus$ ♂ $K_{(5)}\ C_{(5)}\ A_{1+(2)+(2)}\ G_0$.

Female flower – $\oplus$ ♀ $K_{(5)}\ C_{(5)}\ A_0\ \overline{G_{(3)}}$.

F.D. (Floral Diagram)

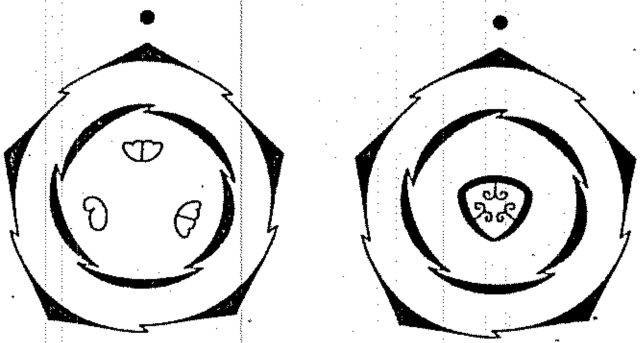


Fig. 19.10. Floral Diagrams of male and female flowers of *Cucurbita maxima* (Kaddu)

Distinguishing features of the family

1. Stem is usually pentangular and hollow.
2. Presence of leaf opposed branched tendrils.
3. Unisexual and epigynous flowers.
4. Usually gamopetalous condition (although placed in polypetalae).
5. Usually $2\frac{1}{2}$ stamen condition (maximum variation from polyandry to synandry).
6. Tricarpellary, syncarpous gynaecium with inferior ovary and parietal placentation.
7. Fruit–Pepo.

Economic Importance of family

Members of this family are commonly known as 'gourds.' These are sources of food (vegetables and fruits), medicines, etc.

(I) Vegetables

(i) *Cucurbita maxima* (Great pumpkin or Vilayati Kaddu or Red pumpkin).

(ii) *C. moschata* (Pumpkin or Sitaphal).

(iii) *C. pepo* (Field pumpkin or Safed kaddu).

(iv) *Citrullus vulgaris* var. *fistulosus* (Tinda or Dil pasand).

(v) *Lagenaria vulgaris* (Bottle gourd or Lauki).

- ○ Hollow, dried fruits of *Lagenaria siceraria* are used for making 'beens' (musical instruments) by snake charmers or 'saperas'.

(vi) *Luffa cylindrica* Syn. *L. aegyptica* (Bath sponge or Ghia tori).

(vii) *L. acutangula* (Kali tori).

(viii) *Momordica charantia* (Bitter gourd or Karela).

(ix) *Trichosanthes anguina* (Snake gourd or Chichinda).

(x) *T. dioica* (Pointed gourd or Parwal).

(II) Fruits

(i) *Cucumis melo* (Kharbooza).

(ii) *Cucumis sativus* (Cucumber or Khira).

(iii) *Cucumis utilissimus* (Kakri).

(iv) *Cucumis melo* var. *momordica* (Phunt).

(v) *Citrullus vulgaris* (Water melon or Tarbooz).

(vi) *Benincasa hispida* (Ash gourd, Wax gourd or White gourd or Petha)– Famous sweet 'Petha' is prepared from it.

- ○ Hollow dried fruits are used for making 'Sitar'.

(III) Medicinal plants

(i) *Coccinia indica* (Kandoori) : Extracts of root, leaf and fruit are used in treatment of diabetes.

(ii) *Citrullus colocynthis* (Indrayan) : Colocynthis alkaloid is obtained from its fruits, which is used in treatment of snake bite, rheumatism, etc.

(iii) *Ecballium elatarium* : Elatarium is obtained from fruits, which is used in treatment of hydrophobia and malaria.

FAMILY–COMPOSITAE OR ASTERACEAE (SUNFLOWER FAMILY)

This is the **largest family of flowering plants,** which includes about 950 genera and 20,000 species. The members of this family constitute more than 10% of the total number of species of angiosperms. The plants of this family are distributed throughout the world.

Phanerogams
Dicotyledons
Gamopetalae
Inferae
Asterales
Asteraceae

- Important plants of this family are– *Tagetes* (Marigold), *Helianthus* (Sunflower), *Lactuca* (Lettuce), *Chrysanthemum*, *Carthamus* (Safflower or Kusum), *Parthenium* (Carrot grass or Congress grass).

Chief vegetative features

The plants are mostly herbs, rarely shrubs or trees.

- Stem and roots generally have **oil ducts** or oil passages.
- Many species are having **milky sap** in their parts.

Inflorescence

Head or capitulum, a type of racemose in which many sessile flowers are present or borne on a common flat concave or convex receptacle.

This head is surrounded by an **involucre** (whorl of bracts) at its base, which is protective in function.

- Number of flowers in a head varies from 1 *(Echinops)* to few thousand *(Helianthus)*.
- Commonly, there are 2 types of **florets or flowers** in a head:

(a) **Outer or peripheral ray florets :** These are zygomorphic, ligulate, neuter or female.

(b) **Inner or central disc florets :** These are actinomorphic, tubular and bisexual.

Such heads having 2 types of florets are called **heterogamous heads.**

- In *Xanthium*, heads are **homogamous,** *i.e.*, having only one type of florets.
- In a head or capitulum, all the flowers or florets can be pollinated by even a single insect, so it is an advanced type of inflorescence.

Flower

Bracteate, sessile, actinomorphic (disc florets) or zygomorphic (ray florets), bisexual or unisexual, epigynous, pentamerous.

Calyx

5 sepals, which are generally reduced to persistent tufts of hairs or thin membranes (pappus), which help in dispersal of fruits.

Corolla

5 petals, gamopetalous, tubular in disc florets and ligulate or strap shaped in ray florets, aestivation– valvate.

Androecium

5 stamens, epipetalous, **syngenesious,** *i.e.*, anthers are fused (filaments free), anthers–dithecous and introrse.

Gynaecium

Bicarpellary, syncarpous, ovary– **inferior,** unilocular with **basal placentation** (having single basal ovule).

Fruit

Cypsella, *i.e.*, achene with persistent **hair or pappus.**

F.F. (Floral Formula)

Ray florets:

(a) Ligulate and female : $\mathrm{Br.} + ♀\ K_{5\,(\mathrm{pappus})}\ C_{(5)}\ A_0\ \overline{G_{(2)}}$.

(b) Ligulate and neuter : $\mathrm{Br.} + K_{5\,(\mathrm{pappus})}\ C_{(5)}\ A_0\ G_0$.

Disc florets:

$$\mathrm{Br.}\ \oplus\ ⚥\ K_{5\,(\mathrm{pappus})}\ \overset{\frown}{C_{(5)}\ A_{(5)}}\ \overline{G_{(2)}}.$$

F.D. (Floral Diagram)

(See Floral digram on next page)

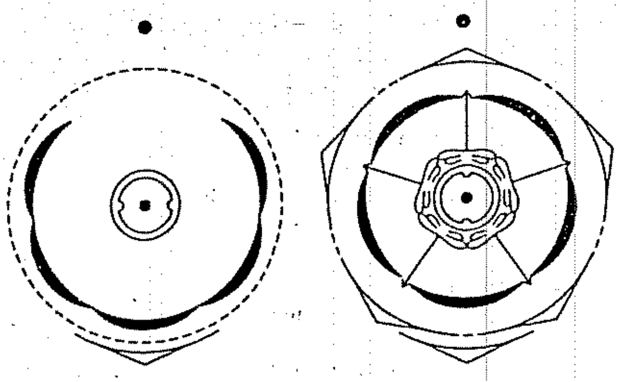


Fig. 19.11. Floral Diagrams of Ray and Disc florets of *Helianthus annuus* (Surajmukhi)

Distinguishing features of the family

1. Plants generally herbs having oil ducts in stem and root.
2. Inflorescence– head or capitulum.
3. Epigynous flowers.
4. Sepals are reduced to hairy 'pappus'.
5. 5 epipetalous stamens with syngenesious condition.
6. Bicarpellary, syncarpous gynaecium with basal placentation.
7. Cypsella fruits.

o This family is considered to be highly evolved or advanced family, because of:

(a) Surity in pollination.

(b) Due to single basal ovule, better development of seed occurs.

~~(c) Syngenesious condition, etc.~~

Economic Importance of the family

The plants of this family are sources of food, oil, medicines, dye, rubber, etc. Besides, a large number of plants are ornamentals and weeds.

(I) Sources of food

(i) *Cichorium intybus* (Chicory or Kasni)– Roots are source of **'Chicory powder'**, which is used for blending coffee.

(ii) *Lactuca sativa* (Garden lettuce or Salad)–This is a salad crop and leaves provide a valuable salad throughout the world.

(iii) *Helianthus tuberosus* (Jerusalem artichoke or Hathichuk)–The tubers are source of food or vegetable (having plenty of Inulin).

(iv) *Trogopogen porrifolium* (vegetable oyster)– Edible.

(II) Sources of medicines

(i) *Artemisia cina* or *A. maritima* (worm weed)– A wormicide (anthelmintic) **'Santonin'** is obtained from **dried unopened flower heads**, which is used as vermifuge or in expelling the intestinal worms.

(ii) *Arnica montana*–This plant yields **'Arnica'**, which is used as hair vitalizer.

(iii) *Eclipta prostrata* (bhringraj)– Its extract is used as hair tonic.

(iv) *Calendula officinalis*– **'Calendula'** drug obtained from dried ligulate florets is used in sprains.

(v) *Taraxacum officinale* (Common dendelion)– Drug **'Taraxacum'** obtained from roots and rhizomes is used as laxative and liver tonic.

(III) Sources of insecticide

(i) *Chrysanthemum marschallii* and *C. cinerariaefolium* (Guldaodi)– Flower heads are source of a commercial insecticide **'Pyrethrum'**.

(IV) Sources of oils

(i) *Carthamus tinctorius* (Safflower or Kusum)– Seeds yield oil, which is edible and because it has high percentage of unsaturated fatty acid, so it is very good for heart patients. The oil is also used in soaps, varnishes, paints, etc.

o A red dye **'Kusum'** is also obtained from its flowers, which is used in foods as well as clothes.

(ii) *Helianthus annuus* (Sunflower or Surajmukhi)– Seeds are source of edible fatty oil.

(V) Sources of rubber

(i) *Taraxacum kok-saghyz* (Russian dendelion)– Roots contain latex, which is the source of **'Dendelion rubber.'**

(ii) *Parthenium argentatum*– In America, **Guayule rubber**, is obtained from this plant, because **'caoutchouc'** granules are present in plant body.

(VI) Ornamentals

(i) *Helianthus annuus* (Sunflower).

(ii) *Tagetes* sps. (Marigold or Genda).

(iii) *Chrysanthemum* sps. (Guldaodi).

(iv) *Calendula officinalis* (Pot marigold).

(v) *Cosmos bipinnatus.*

(vi) *Zinnia elegans.*

(vii) *Dahlia pinnata*, etc.

(VII) Others

(i) *Parthenium hysterophorous* or *P. argentatum* (Carrot grass or Congress grass).

o This is an American plant, which is nowadays **most troublesome terrestrial weed in India.** Skin allergy is caused by this plant (contains **trans-cinnamic acid**).

(ii) *Ambrosia artemissifolia* (Rugweed)– An allergic fever called **'Hay fever'** is caused by pollens of this plant (aeroallergen).

FAMILY–SOLANACEAE (POTATO FAMILY)

The plants of this family are cosmopolitan in distribution, *i.e.*, present in all parts of the world. Important plants of this family are: Potato, Tomato, Brinjal, Datura, *Nicotiana* (Tobacco), *Petunia*, *Cestrum*, etc.

Phanerogams
Dicotyledons
Gamopetalae
Bicarpellatae
Polemoniales
Solanaceae

Chief vegetative features

The plants of this family are generally annual or perennial herbs.

- Bicollateral vascular bundles in the stems.
- Petiole of leaf remains attached to the stem for a distance and hence leaves appear to arise from a higher level.

Inflorescence

Generally flowers are arranged in axillary or extra axillary cymes. In some cases, flowers are solitary.

Flower

Generally bracteate, pedicillate, generally actinomorphic (rarely zygomorphic), bisexual or hermaphrodite, hypogynous, pentamerous.

Calyx

5 sepals, gamosepalous, calyx generally persistent, *i.e.*, remain attached to fruits also.

In *Physalis* accrescent calyx forms membranous covering around fruit.

Aestivation—generally valvate.

Corolla

5 petals, gamopetalous, variously shaped, *e.g.*, funnel shaped (infundibulum) in *Petunia* and *Datura*, bell shaped (companulate) in *Physalis* or rotate in *Solanum*, generally aestivation is valvate.

Androecium

5 stamens, polyandrous, epipetalous.

- Filaments of stamens are of unequal lengths.

Anthers—dithecous and introrse.

Gynaecium

Typically bicarpellary, syncarpous, ovary-superior, bilocular with axile placentation.

- Sometimes ovary becomes **tetralocular** due to false septum.
- Ovary obliquely placed and generally swollen placenta.
- The oblique position of ovary in Solanaceae is due to turning of posterior carpel to right (through 45° from median) and anterior carpel to left.
- A hypogynous nectariferous disc is generally present at the base of ovary.

Fruit

Generally capsule or berry.

F.F. (Floral Formula)

$$\mathrm{Br.}\ \oplus\ ⚥\ K_{(5)}\ \overset{\frown}{C_{(5)}\ A_5}\ \underline{G_{(2)}}.$$

F.D. (Floral Diagram)

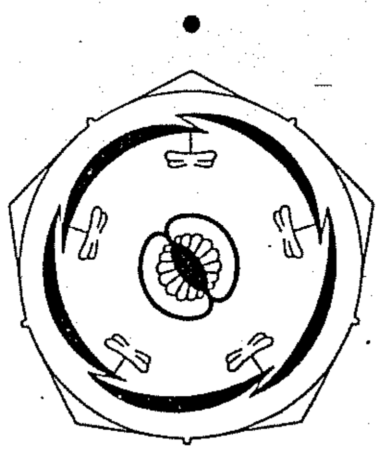


Fig. 19.12. Floral Diagram of *Solanum nigrum* (Makoa)

Distinguishing features of the family

1. Petioles of leaves attached to stem for some distance.
2. Generally 5, persistant sepals.
3. 5 stamens having filaments of unequal lengths.
4. Ovary obliquely placed with swollen placenta.

Economic importance of the family

This family is economically of great importance to mankind as it has many food, medicinal and ornamental plants. Besides, tobacco is also a gift of this family.

(I) Food plants

(i) *Solanum tuberosum* (Potato or Alu): Most important stem vegetable (tubers) in the world.

(ii) *Solanum melongena* (Egg plant or Brinjal): Fruits are source of vegetable.

(iii) *Lycopersicon esculentum* (Tomato or Love apple): Fruits are source of vegetable and salad.

(iv) *Capsicum annuum* (Chillies or Red Pepper): Fruits are source of spices.

(v) *C. frutescens* (Shimla Mirch): Fruits are used as vegetable.

(vi) *Physalis peruviana* (Raspberry or Cape gooseberry): Orange red berries are edible as fruits.

(II) Medicinal plants

(i) *Atropa belladona* (Belladona or Sag–Angoor): Roots are source of an alkaloid–'**Atropine**' which is the basis of **belladona drug** and belladona plasters.

(ii) *Datura stramonium* (Datura or Jimsonweed): Drug '**Stramonium**' is obtained from dried leaves and flowering tops, which is used in treatment of asthama. Atropine, hyoscyamine and hyocine alkaloids are also obtained from this.

○ Seeds of this plants are deadly poisonous.

(iii) *Hyoscyamus niger* (Henbane): Drug **Henbane** is obtained from dried leaves and flowering tops, which is used for sedation and also in asthama and whooping cough.

(iv) *Withania somnifera* (Asgandha) : Drug Asgandh is obtained from its roots, which is used in rheumatism, female troubles and cough.

(III) Source of tobacco

Nicotiana tabacum (tobacco) : The fermented leaves of this plant are source of tobacco, which is used for smoking, chewing and snuffing.

- It is source of alkaloid–'**Nicotine**' and highest nicotine content is present in *Nicotiana rustica.*
- This plant is also used as an insecticide, medicine (antispasmodic sedative) and seeds provide oil, which is used in paints and varnishes.

(IV) Ornamentals

(i) *Petunia alba, P. hybrida* : Flowers of different colours like white, pink, etc.

(ii) *Cestrum nocturnum* (Night Jasmine or Rat Ki Rani).

(iii) *C. diurnum* (Day Jasmine or Din Ka Raja).

(iv) *Nicotiana alata.*

(v) *Brunfelsia hopeana* (Yesterday, today, tomorrow plant).

(vi) *Schizanthus* (Butterfly flower).

(vii) *Salpiglossis*, etc.

(V) Others

(i) *Solanum nigrum* (Night shade plant or Makoa).

FAMILY– LILIACEAE (LILY FAMILY)

The plants of this family are cosmopolitan in distribution, *i.e.*, distributed all over the world. Important plants of this family are: Onion (*Allium cepa*), Garlic (*Allium sativum*), *Asparagus*, Lily (*Lilium*), *Dracaena*, *Yucca*, *Gloriosa*, *Smilax*, etc.

Phanerogams
Monocotyledons
Coronarieae
Liliaceae

Chief vegetative features

The plants are mostly perennial herbs, perennating by means of rhizomes or bulbs or corms, etc. Some plants are shrubs (*Dracaena* and *Yucca*) or small trees.

- *Smilax* and *Asparagus* are shrubby climbers.
- Cladodes (axillary branch modified into leaf-like structures) are present in *Asparagus* and *Ruscus*.
- In *Smilax* leaf stipules are modified into tendrils, whereas in *Asparagus*, leaves are modified into spines.
- In *Gloriosa*, leaf apex tendrils are present.
- Parallel venation in leaves, but in *Smilax*, venation is reticulate.

Inflorescence

Generally raceme, but solitary flowers are also present in some cases *(Lilium, Gloriosa).*

Flower

Bracteate, pedicillate or sub-sessile, actinomorphic, hermaphrodite or bisexual, but rarely unisexual (*Smilax* and *Ruscus*), hypogynous, *trimerous.

Perianth

6 tepals in 2 whorls of 3 each (3 + 3), polyphyllous or sometimes gamophyllous *(Allium)*, generally petaloid (*i.e.*, petal like), may also be sepaloid (*i.e.*, sepal-like) or differentiated into calyx and corolla.

Androecium

6 stamens in 2 whorls of 3 each (3 + 3), polyandrous, these are always opposite the tepals, *i.e.*, **antiphyllous** (not alterniphyllous), anthers– dithecous and introrse.

Sometimes the stamens of outer whorl are reduced.

Gynaecium

Tricarpellary, syncarpous, ovary-superior, trilocular with axile placentation, many ovules in each locule, style-simple and stigma is trilobed.

Fruit

Generally capsule or berry.

F.F. (Floral Formula)

$$\text{Br.}\ \oplus\ \text{⚥}\ \underset{\text{or }(3+3)}{P_{3+3}}\ A_{3+3}\ \underline{G}_{(3)}.$$

F.D. (Floral Diagram)

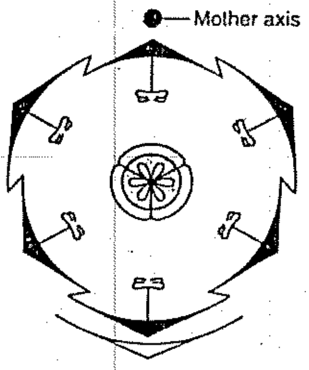


Fig. 19.13. Floral Diagram of *Allium cepa* (Piaz)

Distinguishing features of the family

1. Plants are generally perennial herbs.
2. Trimerous flowers.
3. 6 tepals (units of perianth) in 2 whorls of 3 each.
4. 6 stamens in 2 whorls of 3 each, **antiphyllous,** *i.e.*, opposite the tepals.
5. Tricarpellary, syncarpous gynaecium, trilocular ovary with axile placentation.

Economic importance of the family

The plants of this family are sources of food, drugs, fibres, besides ornamentals.

(I) Sources of food

(i) *Allium cepa* (Onion or Piaz) : The bulbs are source of vegetable. Fresh juice is having bactericidal, diuretic and stimulative properties.

(ii) *Allium sativum* (Garlic or Lahsun) : It is important condiment plant. The essential oil present in it reduces blood cholesterol and hence considered to be good for heart patients.

(iii) *Asparagus officinalis* and *A. racemosus* (Satawar): Fleshy shoots and roots are used as vegetable. Also used in rheumatism.

(II) Sources of medicines کوارگندل

(i) *Aloe vera* (Aloe or Ghee Kawar) : Used in many laxative preparations and also used in curing piles and fissures.

(ii) *Colchicum luteum* and *C. autumnale* (Hirantutiya) : An alkaloid **'Colchicine'** is obtained from seeds and corms, which is used in the cure of rheumatism and liver disorders.

○ It is also drug of choice in acute gout.

Besides **Colchicine** is used for inducing polyploidy in plant breeds by arresting or breaking spindle formation.

(iii) *Urginea indica* and *U. maritima* (Indian squill)– Bulbs stimulate heart and are also used in rheumatism and skin diseases.

○ Raticide or Red-squill is prepared from bulbs of red variety, which is an important raticide (rat killer) for more than 20 years.

(iv) *Fritillaria roylei* : Bulbs are used in rheumatism.

(v) *Smilax macrophylla* and *S. glabra* (Sarasparilla) : Roots provide a drug called **'Sarasparilla'** which is cure of venereal and skin diseases.

(vi) *Gloriosa superba* (Malabar glory lily) : Tubers are used in promotion of labour pains and juice of leaves is used for killing lice.

(III) Source of fibres

(i) *Sansevieria roxburghiana* (Bowstring hemp) : Leaves provide a strong fibre, which is used for making bowstrings and fishing nets.

(ii) *Yucca filamentosa* (Dagger plant) : Leaves provide fibres used for cordage.

(IV) Ornamentals

(i) *Asparagus plumosus* (Asparagus fern).

(ii) *Dracaena* (Dragon plant) : Woody shrub with beautiful foliage.

(iii) *Gloriosa superba.*

(iv) *Yucca gloriosa* : White flowers giving perfume during night.

(v) *Lilium bulbiferum* (Lily) : For beautiful flowers.

(vi) *Tulipa* sps. (Tulip) : Beautiful flowers, etc.

MAIN POINTS OF SOME OTHER IMPORTANT FAMILIES

FAMILY—RANUNCULACEAE (BUTTERCUP FAMILY)

- This is the simplest family according to Bentham and Hooker and most primitive family according to Hutchinson.

Phanerogams
Dicotyledons
Polypetalae
Thalamiflorae
Ranales
Ranunculaceae

- Plants are mostly annual or perennial herbs.
- Presence of scattered vascular bundles (like monocots) in stems of some of the members of this family (*e.g.*, *Thallictrum, Actaea*).
- 5 Sepals which are generally **petaloid** (petal like) and fall off very early (caducous).
- 5 petals with nectaries at their bases.
- Stamens are numerous (∞) free, and spirally arranged with dithecous and extrorse anthers.
- Polycarpellary, apocarpous (free) condition of gynaecium and carpels are spirally arranged. Placentation variable (marginal, basal or axile).
- **Fruits :** generally aggregate (etaerio of achenes, etaerio of follicles or berries).
- **F.F. (Floral Formula) :** Br. Brl. ⊕ ⚥ $K_5\ C_5\ A_\infty\ \underline{G_\infty}$.

F.D. (Floral Diagram)

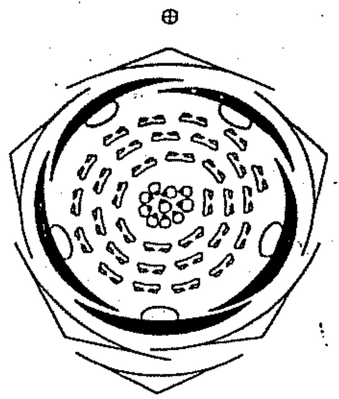


Fig. 19.14. Floral Diagram of *Ranunculus scleratus* (Buttercup)

- Main economically important plants of this family are :

(i) *Aconitum heterophyllum* (Atis) : Roots are source of 'Aconite' alkaloid and used in blood pressure.

(ii) *Anemone pulsatilla* : **'Pulsatilla'** medicine is obtained, which is nervine tonic and also used in women problems.

(iii) *Ranunculus ficaria* : Used in treatment of piles.

(iv) *Thallictrum foliosum* (Mamira) : Used for ophthalmic or eye diseases.

(v) *Nigella sativa* (Kalounji) : Seeds are used as condiments.

(vi) Ornamental plants : *Ranunculus*, *Delphinium* (Larkspur), *Clematis* (Old man's' beard or Virgin's bower), *Paeonia*, etc.

FAMILY–GRAMINEAE OR POACEAE

- The members of this family are commonly known as 'grasses'.
- Plants are mostly herbs having stem with marked solid nodes and hollow internodes, *i.e.*, **stem is culm.** Further stem is generally circular and hollow.

Phanerogams
Monocotyledons
Glumaceae
Gramineae or Poaceae

- Leaves simple, alternate, with sheathing bases and ligulate (*i.e.*, a membranous outgrowth **'ligule'** is present at junction of leaf sheath and leaf lamina).
- Spikelet (not flower) is the unit of inflorescence, which may be arranged in spike or panicle, *i.e.*, inflorescence is spike of spikelets or panicle of spikelets.
- Each spikelet is having 1 – 5 flowers on a reduced axis, which bear two leaf like structures (**glumes**) at base. Each flower is in axil of other leaf like structure called **'lemma'** (bract). On the flower axis is another leaf-like structure called **palea** (bracteole). Above palea are two scale like **lodicules** (perianth).
- Flower is hypogynous and zygomorphic.
- Perianth reduced and represented by lodicules.
- Generally 3 stamens with dithecous and versatile anthers.
- Carpel is generally 1, unilocular ovary with basal placentation, 2 long styles ending in **feathery stigmas.**
- Fruit is **karyopsis or grain** (single seeded indehiscent fruit, in which seed coat fuses with fruit wall to form husk).
- **F.F. (Floral Formula) :** Br. Brl. + ⚥ $P_{2\,(\text{lodicules})}$ A_3 or $3+3$ $\underline{G_1}$

F.D. (Floral Diagram)

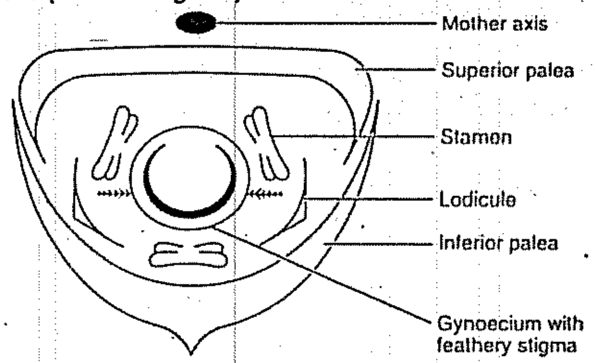


Fig. 19.15. Floral Diagram of *Triticum aestivum* (Wheat)

- Economically important plants of this family are:

(I) Cereals and millets :

Most important source of food in the world is cereals having **karyopsis or grain fruit,** *e.g.*, *Triticum vulgare* (Wheat), *Zea mays* (Maize), *Oryza sativa* (Rice), *Avena sativa* (Oat), *Hordeum vulgare* (Barley).

Small sized grains constitute **millets,** which also provide food, *e.g.*, *Sorghum vulgare* (Jawar), *Pennisetum typhoides* (Bajra), *Eleucine coracana* (Ragi or Mandua).

(II) Source of sugar :

Saccharum officinarum (Sugar cane) : Most important source of sugar in world.

(III) Other plants :

(i) *Bambusa* sps.

(ii) *Dendrocalamus* sps. : Both (i) and (ii) **provide** bamboo for chairs, baskets, poles, etc.

(iii) *Cynodon dactylon* (Doob grass) : Fodder.

(iv) *Andropogon muricatus* (Khas) : Roots provide khas oil.

Brassica campestris
Raphanus sativus

→ Cruciferae or Brassicaceae — [illegible]
→ Malvaceae —
→ Leguminosae
— Papilionaceae → Pisum sativum, Vigna radiata, Vigna mungo, Arachis hypogea, Cicer arietinum, Lathyrus odoratus
— Caesalpiniaceae → Cassia, Tamarindus indica, Bauhinia variegata
— Mimosoideae → Mimosa pudica, Acacia [illegible]
→ Compositae or Asteraceae → Helianthus [illegible]
→ Cucurbitaceae → Cucurbita maxima, C. pepo, Cucumis sativus, Citrullus vulgaris, [illegible]
→ Solanaceae → S. tuberosum, [illegible]
→ Liliaceae → [illegible]
→ Ranunculaceae → Ranunculus, Nigella [illegible]
→ Gramineae → Triticum aestivum, Hordeum vulgare, Zea mays, Oryza sativa, Avena sativa, Bambusa, [illegible]

Taxonomy — A

MULTIPLE CHOICE QUESTIONS

1. Who is known as 'Father of Taxonomy' (Modern Botany)?
(a) Lamarck [✓ (b) Linnaeus]
(c) Theophrastus (d) None of these

2. Who coined the term 'Systematics'?
(a) Huxley [✓ (b) Linnaeus]
(c) Darwin (d) Lamarck

3. The term 'Taxonomy' was given by:
(a) Theophrastus (b) Bentham and Hooker
(c) Rendle [✓ (d) A.P. de Candolle]

4. Plants, whose male and female flowers are found on separate plants:
[✓ (a) Dioecious] (b) Monoecious
(c) Heteroecious (d) Autoecious

5. Whorl of bracts which enclose a cluster of flowers are said to be:
(a) Tepals (b) Epicalyx
[✓ (c) Involucre] (d) Stipules

6. Epicalyx is:
(a) Additional whorl of calyx
(b) Involucre
(c) Whorl of bracts
[✓ (d) A whorl of bracteoles]

7. Tetradynamous condition is:
(a) 6 stamens—2 long + 4 short
(b) 6 stamens—2 short + 4 long
[✓ (c) 4 stamens—2 long + 2 short]
(d) None of the above

8. Ovule is attached to placenta by:
(a) Hilum (b) Pedicel
(c) Petiole [✓ (d) Funicle]

9. 'Gynobasic' style is found in:
[✓ (a) Lamiaceae (Labiatae)] (b) Poaceae
(c) Liliaceae (d) Compositae

10. Monocarpic plant is:
(a) Has only one carpel (b) Flowers once in life
(c) Produces one seed (d) Produces one fruit

11. Largest flower in world is:
(a) Sunflower (b) Giant cactus
(c) Rafflesia (d) Lotus

12. National flower of India is:
(a) Rose (b) *Wolffia*
(c) Lotus (d) *Tagetes*

13. In monocot flower, we can find:
(a) Sepal (b) Petal
[✓ (c) Tepal] (d) None of these

14. 'Cauliflory' is:
(a) Production of flowers on old stem
(b) Flowers on young branches
(c) Plant which produces cauliflower
(d) Flowers in clusters

15. Cauliflory is found in:
(a) *Syzygium* (b) *Litchi*
(c) *Artocarpus* (d) *Morus*

16. 'Gynostegium' is found in:
(a) Asclepiadaceae (b) Moraceae
(c) Solanaceae (d) Fabaceae

17. 'Stylopodium' is found in:
(a) *Calotropis* (b) Coriander
(c) Cucumber (d) *Ocimum*

18. A bisexual flower, which never opens in its life:
(a) Homogamous (b) Heterogamous
[✓ (c) Cleistogamous] (d) Dichogamous

19. Maturation of stamens and pistils at different times is:
[✓ (a) Dichogamy] (b) Herkogamy
(c) Heterospory (d) Dicliny

20. 'Ligule' is characteristic of:
(a) Compositae [✓ (b) Poaceae]
(c) Cypraceae (d) None of these

*21. Monocarpic plant is:
(a) Cactus (b) *Yucca*
(c) *Dracaena* [✓ (d) Bamboo]

22. 'Lever Mechanism' of pollination is found in:
(a) *Salvia* (b) Orchids
(c) Mango (d) *Ficus*

23. Which is called 'Sexual System' of classification?
(a) Bentham and Hooker's (b) Tippo's
[✓ (c) Linnaeus] (d) Takhtajan

24. Which is natural system of classification? **(CPMT 1992)**
(a) Linnaeus (b) Bessey's
[✓ (c) Bentham and Hooker's] (d) Engler and Prantl's

25. Who placed gymnosperms in between angiosperms?
(a) Linnaeus (b) Hutchinson
[✓ (c) Bentham and Hooker] (d) Bessey

26. Bentham and Hooker gave:
(a) 212 families (b) 222 families
(c) 280 families [✓ (d) 202 families]

27. 'Amentiferae' group was considered to be most primitive by:
(a) Bentham and Hooker (b) Takhtajan
[✓ (c) Engler and Prantl] (d) Hutchinson

28. Binomial system of nomenclature was given by:
(CPMT 1997, 2002; AFMC 1997; MPPMT 2001)
(a) Lamarck [✓ (b) Linnaeus]
(c) Theophrastus (d) None of these

29. In bionomial system, most of the words are:
(a) Greek [✓ (b) Latin]
(c) Italian (d) English

30. Which name of potato is correct?
(a) *Solanum tuberosum*, L. (b) *Solanum, tuberosum* L.
[✓ (c) *Solanum tuberosum* L.] (d) *Solanum-tuberosum*, L.

31. The lettter 'L' at the end of name in above question, indicates:
(a) Latin language [✓ (b) Linnaeus]
(c) Lamarck (d) Variety

32. Which is a tautonym?
[✓ (a) *Malus malus*] (b) *Ficus elastica*
(c) *Solanum tuberosum* (d) None of these

33. Tautonyms are illegitimate in:
[✓ (a) Plants] (b) Animals
(c) Both (a) and (b) (d) None of these

34. Size of herbarium sheet is:
(a) $11'' \times 16\frac{1}{2}''$ [✓ (b) $11\frac{1}{2}'' \times 16\frac{1}{2}''$]
(c) $11\frac{1}{2}'' \times 16''$ (d) $11'' \times 16''$

35. Largest herbarium of world is of :
(a) Berlin botanical garden
[✓ (b) Kew, Great Britain]
(c) Paris, France
(d) Kolkata, India

36. Largest herbarium of India is:
(a) N.B.R.I., Lucknow (b) I.B.G., Kolkata
(c) F.R.I., Dehradun (d) Coimbatore

37. Smallest flowers are in:
(a) *Lemna* [✓ (b) *Wolffia*]
(c) Orchids (d) *Iberis*

38. Oldest available literature in botany is:
(a) Species Plantarum (b) Philosophia Botanica
[✓ (c) Historia Plantarum] (d) None of these

39. 'Species Plantarum' was written by: **(BHU 1990)**
[✓ (a) Linnaeus] (b) Darwin
(c) Theophrastus (d) Bentham and Hooker

40. Who is author of work 'Philosphia Botanica'?
(a) Bessey (b) A.P. de Candolle
[✓ (c) Linnaeus] (d) None of these

41. Simplest order according to Bentham and Hooker is:
(a) Parietales [✓ (b) Ranales]
(c) Pandanales (d) Graminiales

42. 'Pappus' is modification of:
(a) Thalamus (b) Hair
[✓ (c) Calyx] (d) Corolla

43. Persistent calyx is found in:
(a) Malvaceae (b) Compositae
(c) Solanaceae (d) Liliaceae

44. Apocarpous condition is in:
(a) *Ranunculus* (b) *Datura*
(c) Cotton (d) Pea

45. Syngenesious condition is in: **(AFMC 1997)**
(a) Cruciferae (b) Malvaceae
(c) Compositae (d) None of these

46. In racemose inflorescence:
(a) Youngest flower at top
(b) Oldest in centre
(c) Youngest in the middle
(d) None of the above

47. A phyllode is a:
(a) Modified stem (b) Modified root
(c) Modified flower (d) Modified leaf

48. 'Systema Naturae' was written by:
(a) Engler and Prantl (b) Wallace
(c) C. Linnaeus (d) Darwin

49. Most advanced family among dicots is:
(a) Malvaceae (b) Solanaceae
(c) Cucurbitaceae (d) Compositae

***50.** Linnaeus considered:
(a) Species as a static entity (b) Variable entity
(c) Dynamic entity (d) None of these

51. Diadelphous condition of stamens is in: **(Uttaranchal PMT 2001)**
(a) Caesalpiniaceae (b) Mimosaceae
(c) Papilionaceae (d) Solanaceae

52. Inflorescence of wheat is :
(a) Spike (b) Spikelet
(c) Spike of spikelets (d) Panicle of spikelets

53. Nocturnal flowers for attracting insects produce:
(a) Nectar (b) Coloured petals
(c) Scent (d) Coloured sepals

54. Cyathium is a cup shaped inflorescence found in:
(a) Sunflower (b) *Ficus*
(c) Mulberry (d) *Euphorbia*

55. Taxon refers to: **(Raj. PMT 2001)**
(a) Species (b) Genus
(c) Family (d) Group of any rank

56. Ascending order of ranks of taxa are: **(CBSE 1999; CET Karnataka 2001)**
(a) Genus, species, order, family
(b) Species, genus, family, order
(c) Species, genus, order, family
(d) Family, order, genus, species

57. Apiaceae is the new name of:
(a) Compositae (b) Guttiferae
(c) Umbelliferae (d) None of these

58. New name of Gramineae is:
(a) Asteraceae (b) Poaceae
(c) Cypraceae (d) Clausiaceae

59. If in botanical name, an epithet consists of 2 words, what is done?
(a) One word is abolished (b) Comma is inserted
(c) Hyphened (d) Nothing is done

60. The speciman or element designated by author as nomenclatural type is:
(a) Holotype (b) Isotype
(c) Lectotype (d) Neotype

61. The correct name of 'Fenugreek' is:
(a) *Trigonella foenum-graecum*
(b) *Trigonella foenum graecum*
(c) *Trifolium alexandrianum*
(d) None of the above

62. When the inflorescence axis is branched, it is:
(a) Head (b) Cymose
(c) Umbel (d) Panicle

63. Floral formula represents:
(a) Symmetry of flower
(b) Position of flower
(c) Notation of floral characters
(d) Function of flower

64. Unguiculate petals are characteristic of:
(a) Compositae (b) Liliaceae
(c) Cruciferae (d) Labiatae

65. Herbarium is a:
(a) Collection of animals
(b) Collection of plants
(c) Collection of plants and animals
(d) None of the above

66. In maize and banana, inflorescence is:
(a) Spadix (b) Spike
(c) Catkin (d) Corymb

67. When pedicillate, bisexual flowers are borne acropetally, it is:
(a) Spike (b) Raceme
(c) Spikelit (d) Head

68. Epigynous condition is where:
(a) Ovary is inferior
(b) Ovary superior
(c) Obliquely placed ovary
(d) Ovary half inferior and half superior

69. 'Genera Plantarum' was published by:
(a) John Ray (b) Bentham and Hooker
(c) Hutchinson (d) Bessey

70. Corolla is infundibulum in:
(a) *Petunia* (b) Pea
(c) *Solanum* (d) Sunflower

71. Arrangement of taxa is:
(a) Natural classification (b) Systematics
(c) Hierarchy (d) Key of taxa

72. Glumes are modified:
(a) Sepals (b) Petals
(c) Bracts (d) Androecium

73. Synandrium is fusion of:
(a) Only anthers
(b) Only filaments
(c) Both filaments and anthers
(d) None of the above

74. In anemophilous flowers, stigma is:
(a) Small (b) Sticky
(c) Hairy (d) Smooth

75. Cleistogamy is found in:
(a) *Ficus* (b) *Commellina*
(c) *Vallisneria* (d) None of these

76. Capitulum is a type of inflorescence found in: **(CPMT 2002)**
(a) *Cosmos* (b) *Petunia*
(c) *Ocimum* (d) *Asphodelus*

77. Gynostegium is characteristic of:
(a) *Tabernimontana* (b) *Calotropis*
(c) *Solanum* (d) *Ambrosia*

78. Inflorescence of *Acacia* is:
(a) Head (b) Spike
(c) Spikale head (d) Spikelet

79. The basic unit of classification or taxonomy is:
(a) Species (b) Genus
(c) Kingdom (d) None of these

80. Siliqua develops from:
(a) Monocarpellary gynaecium
(b) Bicarpellary gynaecium
(c) Polycarpellary gynaecium
(d) Thalamus

81. Linnaeus' classification is based on:
(a) Plant morphology
(b) Type of stem
(c) Number of stamens and other sexual structures
(d) Number of sepals and petals

82. 'Stylopodium' is found in:
(a) *Foeniculum* (b) *Cucumis*
(c) *Lathyrus* (d) *Triticum*

83. Largest petal in papilionaceous corolla is called as:
(a) Alae (b) Vexillum
(c) Keel (d) None of these

84. Superficial placentation is found in:
(a) *Withania* (b) *Yucca*
(c) *Hibiscus* (d) *Nymphaea*

85. The word ending with "oideae" indicates:
(a) Class (b) Order
(c) Sub family (d) Genera

86. 'Kusum' is obtained from a plant belonging to family:
(a) Solanaceae (b) Cucurbitaceae
(c) Asteraceae (d) Malvaceae

87. 'Pappus' is found in:
(a) Asteraceae (b) Liliaceae
(c) Cruciferae (d) None of these

88. An American plant, which is a troublesome terrestrial weed in India is:
(a) *Eichhornia* (b) *Argemone*
(c) *Parthenium* (d) *Chenopodium*

89. 'Hay fever' is caused by:
(a) *Amaranthus* (b) *Parthenium*
(c) *Ambrosia* (d) None of these

90. Seeds of which plant are used by Jewellers for weighing purpose? **(Raj. PMT 2001)**
(a) *Atropa* (b) *Abrus*
(c) *Ambrosia* (d) Horse gram

91. 'Horse gram' is:
(a) *Cicer arietinum* (b) *Cajanus cajan*
(c) *Lens culinaris* (d) *Dolichos biflorus*

92. *Abras precatorius* belongs to family:
(a) Compositae (b) Papilionaceae
(c) Cruciferae (d) None of these

93. Nicotine is obtained from a plant of family:
(a) Solanaceae (b) Malvaceae
(c) Cucurbitaceae (d) Compositae

94. Flowers of Cucurbitaceae are :
(a) Epigynous (b) Hypogynous
(c) Perigynous (d) Amphigynous

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95. Botanical name of 'Money plant' is:
(a) *Alocasia* (b) *Pothos*
(c) *Abrus* (d) *Croton*

96. When the flowers appear to arise from a single point, the inflorescence is:
(a) Capitulum (b) Corymb
(c) Umbel (d) Raceme

97. Bell shaped corolla is called:
(a) Infundibulum (b) Companulate
(c) Ligulate (d) Rotate

98. Pollinia occur in:
(a) *Citrus* (b) *Psidium*
(c) *Calotropis* (d) *Mangifera*

99. Number of similar (resembling) genera are put in:
(a) Family (b) Order
(c) Class (d) Series

100. Papilionaceae, Caesalpiniaceae and Mimosaceae (or three sub-families of Leguminosae) are distinguished by character of: **(CPMT 1992)**
(a) Sepals (b) Carpels
(c) Fruit (d) Petals and androecium

101. In which inflorescence, sessile bisexual flowers are arranged acropetally?
(a) Spadix (b) Spike
(c) Raceme (d) Corymb

102. Which inflorescence is of determinate growth?
(a) Raceme (b) Spike
(c) Panicle (d) Cyme

103. Family Compositae belongs to:
(a) Rosales (b) Asterales
(c) Solanales (d) Malvales

104. Fruit of Gramineae is:
(a) Capsule (b) Achene
(c) Caryopsis (d) Nut

105. The fruit of sunflower is: **(EAMCET 2002)**
(a) Capsule (b) Caryopsis
(c) Cypsella (d) Pepo

106. In Engler and Prantl's system which is incorrect?
(a) Dicots are placed before monocots
(b) Monocots are placed before dicots
(c) Gymnosperms before angiosperms
(d) Archichlamydae before metachamydae

107. Flower is a modified shoot in which:
(a) Nodes are highly condensed
(b) Internodes are highly condensed
(c) Internodes are highly elongated
(d) Nodes are highly elongated

108. The fruit of cruciferae is:
(a) Legume (b) Capsule
(c) Siliqua (d) Berry

109. In natural system of classification, the plants are classified on the basis of:
(a) Number of stamens (b) Number of carpels
(c) Phylogeny (d) Morphology

110. The taxon which includes related families is:
(a) Class (b) Phylum
(c) Order (d) Genus

111. Pulses are obtained from family:
(a) Malvaceae (b) Gramineae
(c) Compositae (d) Fabaceae

112. Pulses are rich in:
(a) Carbohydrates (b) Lipids
(c) Proteins (d) Vitamins

*113. Which is characterised by production of geocarpic fruits? **(CPMT 1990)**
(a) *Cucurbita* (b) *Pisum*
(c) *Glycine* (d) *Arachis*

114. Which family belongs to Thalamiflorae under polypetalae in Bentham and Hooker's classification ?
(a) Cucurbitaceae (b) Malvaceae
(c) Leguminosae (d) Compositae

115. Lemma, palea and lodicules are associated with which family?
(a) Solanaceae (b) Compositae
(c) Liliaceae (d) Poaceae

116. In free central placentation, ovary is:
(a) Unilocular (b) Bilocular
(c) Multilocular (d) Any of these

117. Foliaceous stipules are found in:
(a) Gram (b) Garden pea
(c) Sweet pea (d) *Smilax*

118. A pendent inflorescence, where unisexual, naked flowers are borne acropetally is:
(a) Raceme (b) Ament
(c) Spike (d) Head

119. *Cucumis sativus* is botanical name of:
(a) Sweet potato (b) Cucumber
(c) Coconut (d) Kattha

120. Ascending imbricate aestivation is found in:
(a) *Tamarindus* (b) *Pisum*
(c) *Mimosa* (d) *Helianthus*

*121. A distinct monocot character shown by monocot families is?
(a) Hypogynous flower (b) Actinomorphic flower
(c) Trimerous flower (d) Bisexual flower

122. *Parkinsonia* is example of:
(a) Phylloclade (b) Parachute mechanism
(c) Phyllode (d) Winged fruits

123. Cucurbits are bitter due to:
(a) Stramonium (b) Stanozolol
(c) Triterpenes (d) Steroids

124. Linnaeus died in:
(a) 1767 A.D. (b) 1778 A.D.
(c) 1802 A.D. (d) 1788 A.D.

125. Genera Plantarum of Bentham and Hooker is in:
(a) 1 volume (b) 2 volumes
(c) 3 volumes (d) 23 volumes

126. Red gram is:
(a) *Phaseolus vulgaris* (b) *Cajanus cajan*
(c) *Cicer arietinum* (d) *Dolichos biflorus*

127. Which family belongs to order passiflorales of series calyciflorae of Bentham and Hooker?
(a) Compositae (b) Cucurbitaceae
(c) Leguminosae (d) Liliaceae

128. When many names are given to same species (plant), then which is valid?
(a) The name under which the species was last described
(b) The name under which the species first described
(c) Name given by Linnaeus
(d) All of the above

129. Who gave his phylogenetic classification on the basis of number of 'dicta'?
(a) Eichler (b) Bessey
(c) Hutchinson (d) Engler and Prantl

130. 'Families of flowering plants' was written by:
(a) Linnaeus (b) Bentham and Hooker
(c) Hutchinson (d) Bessey

131. According to Hutchinson, evolution is:
(a) Upwards
(b) Downwards
(c) Both upwards and downwards
(d) None of the above

*132. Which family is most primitive according to Hutchinson ?
(a) Ranunculaceae (b) Magnoliaceae
(c) Both (a) and (b) (d) None of these

133. The term 'Annonopsida' for angiosperms was used by:
(a) Cronquist (b) Takhtajan
(c) Thorne (d) None of these

134. 'Herbarium' making was started by:
(a) Roxburgh (b) George King
(c) Linnaeus (d) Caesalpini

135. Royal botanical garden was established in:
(a) 1841 A.D. (b) 1759 A.D.
(c) 1857 A.D. (d) 1757 A.D.

136. 'Great banyan tree' is outstanding feature of:
(a) Indian botanical garden (b) National botanical garden
(c) Royal botanical garden (d) Berlin botanical garden

137. 'Scape' is present in:
(a) China rose (b) Garlic
(c) *Helianthus* (d) *Commellina*

138. 'Ochreate stipules' are in:
(a) Rubiaceae (b) Polygonaceae
(c) Compositae (d) None of these

139. In which plant stipules are modified into tendrils?
(a) *Gloriosa* (b) *Smilax*
(c) *Asparagus* (d) *Acacia*

140. Most common type of alternate phyllotaxy is:
(a) 1/2 (b) 1/3
(c) 2/5 (d) 3/8

141. Single female flower and a number of male flowers in a cup-shaped involucre constitute inflorescence:
(a) Hypanthodium (b) Cyathium
(c) Verticillaster (d) None of these

142. 'Tassel' is found in:
(a) Wheat (b) *Ocimum*
(c) Maize (d) Fig

143. Minute perianth parts of a grass flower are:
(a) Glumes (b) Palea
(c) Lemma (d) Lodicules

144. 'Androgynophore' is present in:
(a) *Silene* (b) *Stellaria*
(c) *Abutilon* (d) *Cleome*

145. 'Obdiplostemonous' condition is in:
(a) *Malva* (b) *Murraya*
(c) Grasses (d) None of these

146. Versatile anthers are characteristic of:
(a) Ranunculaceae (b) Malvaceae
(c) Gramineae (d) Cruciferae

147. Resupination occurs in flowers of:
(a) Grasses (b) Orchids
(c) Asteraceae (d) None of these

148. The maximum variation from polyandry to synandry occurs in family:
(a) Compositae (b) Liliaceae
(c) Leguminosae (d) Cucurbitaceae

*149. Symmetry of flower is represented by:
(a) Floral diagram (b) Floral formula
(c) Both (a) and (b) (d) None of these

150. In a F. D., the side towards mother axis represents:
(a) Anterior side (b) Posterior side
(c) Lateral side (d) None of these

151. Dry, indehiscent fruit formed from inferior ovary with basal placentation of a bicarpellary syncarpous gynaecium is known as:
(a) Caryopsis (b) Cypsella
(c) Cremocarp (d) Achene

152. Fleshy, indehiscent fruit developed from tricarpellary syncarpous gynaecium, inferior ovary with parietal placentation is:
(a) Hesperidium (b) Pome
(c) Pepo (d) Capsule

*153. A crop plant that grows well in nitrogen deficient soils without addition of manure is:
(a) *Cajanus cajan* (b) *Gossypium herbaceum*
(c) *Helianthus annuus* (d) *Allium sativum*

154. Bicarpellary, syncarpous gynaecium with bilocular ovary, axile swollen placenta and oblique septum occurs in:
(CBSE 2001; Raj. PMT 2001)
(a) Cruciferae (b) Solanaceae
(c) Liliaceae (d) Cucurbitaceae

155. The largest family is:
(a) Fabaceae (b) Solanaceae
(c) Gramineae (d) Asteraceae

156. The placentation in Compositae is:
(a) Marginal (b) Parietal
(c) Axile (d) Basal

157. A genus of ornamental plant which is cultivated for important edible oil from its cypsella fruits, is:
(a) *Helianthus* (b) *Brassica*
(c) *Sesamum* (d) *Cocos*

158. Many vegetable yielding and pulse yielding plants belong to families:
(a) Solanaceae and Liliaceae
(b) Malvaceae and Compositae
(c) Compositae and Fabaceae
(d) Cucurbitaceae and Fabaceae

159. Potato, tomato, brinjal, mustard and okra belong to how many genera?
(a) 5 (b) 4
(c) 3 (d) 2

160. Ascending imbricate aestivation is found in :
(a) *Tamarindus* (b) *Pisum*
(c) *Mimosa* (d) *Helianthus*

161. Character shown by flowers of Liliaceae is:
(a) Hypogynous flowers
(b) Actinomorphic flowers
(c) Trimerous flowers
(d) Bisexual flowers

162. Gynaecium is syncarpous, but ovary is unilocular in family:
(a) Malvaceae (b) Compositae
(c) Labiatae (d) Solanaceae

163. *Colchicum autumnale* belongs to family:
(a) Fabaceae (b) Cucurbitaceae
(c) Liliaceae (d) Cruciferae

164. In Liliaceae, placentation is:
(a) Parietal (b) Free central
(c) Axile (d) Basal

165. F.F. of Solanaceae is: **(DPMT 1997)**
(a) $\oplus$ ⚥ $P_2A_3\underline{G_2}$ (b) $\oplus$ ⚥ $K_{4-5}\,C_{4-5}\,A_{10}\,\underline{G_{(2)}}$
(c) $\oplus$ ⚥ $K_{(5)}\,C_5A_5\,\underline{G_{(2)}}$ (d) $\oplus$ ⚥ $K_{(5)}\,C_{(5)}\,A_5\,\underline{G_{(2)}}$

166. $\oplus$ ⚥ $P_{3+3}\,A_{3+3}\,\underline{G_{(3)}}$ is F.F. of: **(CPMT 1997)**
(a) Cruciferae (b) Malvaceae
(c) Liliaceae (d) Ranunculaceae

167. Placentation in Cruciferae is:
(a) Axile (b) Free-central
(c) Parietal (d) Basal

168. *Asparagus* belongs to family:
(a) Cruciferae (b) Malvaceae
(c) Liliaceae (d) Gramineae

169. Disc florets are:
(a) Ligulate and bisexual (b) Ligulate and unisexual
(c) Tubular and bisexual (d) Tubular and female

170. Stamens in Solanaceae are:
(a) Epiphyllous (b) Synandrous
(c) Syngenesious (d) Epipetalous

171. Androecium in disc florets of Compositae is:
(a) Tetradynamous (b) Monoadelphous
(c) Syngenesious (d) Diadelphous

172. Androecium in Liliaceae is:
(a) Monoadelphous (b) Monothecous
(c) Antiphyllous (d) Alterniphyllous

173. Siliqua develops from: **(EAMCET 1993)**
(a) Monocarpellary ovary (b) Bicarpellary ovary
(c) Polycarpellary ovary (d) Thalamus

174. Flowers in Compositae are:
(a) Epigynous (b) Hypogynous
(c) Perigynous (d) Amphigynous

175. The F.F. $\oplus$ ⚥ $K_5C_5A_{5+5}\,\underline{G_1}$ belongs to :
(a) Rosaceae (b) Fabaceae
(c) Cucurbitaceae (d) Malvaceae

176. 'Sarasparilla' is obtained from:
(a) *Smilax* (b) *Colchicum*
(c) *Ruscus* (d) *Asparagus*

177. Colza is obtained from:
(a) *Brassica campestris* (b) *B. rapa*
(c) *B. juncea* (d) *B. oleracea*

178. Ray florets in Compositae are :
(a) Bisexual (b) Unisexual
(c) Neuter (d) Unisexual or neuter

179. Bicollateral vascular bundles are character of family:
(a) Liliaceae (b) Malvaceae
(c) Cucurbitaceae (d) Leguminosae

180. In *Pisum sativum* :
(a) Leaf modified into tendril
(b) Lower leaflets modified to tendril
(c) Upper leaflets modified to tendril
(d) Terminal leaflet modified into tendril

181. Earliest maximum written work in plants was done by:
(a) Eichler (b) Theophrastus
(c) Bessey (d) Linnaeus

182. $2\frac{1}{2}$ stamen condition is found in:
(a) Compositae (b) Solanaceae
(c) Malvaceae (d) Cucurbitaceae

183. Characteristic of ovary of Cruciferae is:
(a) One row of ovules on each placenta
(b) False septum
(c) Syncarpy
(d) Hypogyny

184. Source of 'Gulal' used in Holi is:
(a) *Caesalpinia coriaria* (b) *C. sappan*
(c) *C. indica* (d) *C. pulcherrima*

185. In Malvaceae, which condition of androecium is found?
(a) Diadelphous condition and introrse anthers
(b) Monoadelphous, extrorse
(c) Monoadelphous, introrse
(d) None of the above

186. 'Exerted' stamens are in:
(a) Papilionaceae (b) Mimosaceae
(c) Caesalpiniaceae (d) Malvaceae

187. *Carthamus tinctorius* belongs to family:
(a) Compositae (b) Malvaceae
(c) Solanaceae (d) Liliaceae

188. *Acacia catechu* belongs to family:
(a) Malvaceae (b) Cucurbitaceae
(c) Mimosaceae (d) Cruciferae

189. Odd sepal is anterior in:
(a) Cruciferae (b) Malvaceae
(c) Caesalpiniaceae (d) Rutaceae

190. Winter ornamental plant *Iberis* is commonly called as:
(a) Pansy (b) Candytuft
(c) Poppy (d) Snapdragon

191. Garlic is beneficial as it reduces:
(a) Blood urea (b) Blood cholesterol
(c) Blood serum (d) None of these

192. Green manure crop is:
(a) Sunflower (b) Sunhemp
(c) Cotton (d) Sugar cane

193. China rose and Lily have one common character:
(a) Showy petals (b) Monothecous anthers
(c) Axile placentation (d) Persistent calyx

194. In Brassicaceae two carpels in ovary are placed:
(a) Anteroposteriorly (b) Transversely
(c) Obliquely (d) Separately

195. *Atropa belladona* belongs to family:
(a) Liliaceae (b) Cucurbitaceae
(c) Cruciferae (d) Solanaceae

196. The carpels of *Solanum* flower are oblique, because:
(a) Posterior and anterior carpels move to the left
(b) Posterior to left and anterior to right
(c) Both turn through 180°
(d) Posterior carpel turn to right and anterior to left

197. Synandry is common in:
(a) Umbelliferae (b) Rosaceae
(c) Malvaceae (d) Cucurbitaceae

198. A plant having stellate hair on stem, mucilaginous sap and reniform anthers belong to family:
(a) Cucurbitaceae (b) Malvaceae
(c) Cruciferae (d) Compositae

199. Botanical name of 'Okra' is:
(a) *Abelmoschus moschatus* (b) *A. esculentus*
(c) *Urena lobata* (d) None of these

200. Plants containing pungent, watery juice belong to:
(a) Brassicaceae (b) Compositae
(c) Liliaceae (d) None of these

201. 'Flame of forest' is:
(a) *Butea monosperma* (b) *Salvia*
(c) *Abras* (d) *Crotolaria juncea*

202. Sickle shaped style is present in:
(a) Pisum (b) Acacia
(c) Cassia (d) None of these

203. 'Touch me not' *(Mimosa)* belongs to family:
(a) Leguminosae (b) Malvaceae
(c) Asteraceae (d) Liliaceae

204. A plant is having pentangular stem and also leaf opposite branched tendrils, it belongs to:
(a) Malvaceae (b) Papilionaceae
(c) Cucurbitaceae (d) None of these

205. 'Wax gourd' is:
(a) *Citrullus vulgaris* (b) *Benincasa hispida*
(c) *Cucumis moschata* (d) *Lagenaria vulgaris*

206. Lettuce belongs to family:
(a) Malvaceae (b) Asteraceae
(c) Fabaceae (d) Cucurbitaceae

207. Which family members show 'surity in pollination'?
(a) Labiatae (b) Cucurbitaceae
(c) Compositae (d) None of these

208. Persistent calyx is found in:
(a) *Capsicum* (b) *Hibiscus*
(c) *Gloriosa* (d) *Smilax*

209. Drug 'Stramonium' is obtained from plant of family:
(a) Malvaceae (b) Solanaceae
(c) Compositae (d) None of these

210. Leaf apex tendrils are found in:
(a) *Clematis* (b) *Lathyrus*
(c) *Smilax* (d) *Gloriosa*

211. The characteristic flavour of onion is due to:
(a) Volatile oil (allyl sulphide)
(b) Auxins
(c) Steroid
(d) Alkaloid cepacin

212. In *Albizzia labbeck* (L.) Benth., (L.) and Benth. represent:
(a) First described by Bentham and later corrected by Linnaeus
(b) First described by Linnaeus and later corrected by Bentham
(c) Described by Linnaeus and Bentham combinedly
(d) None of the above

213. Hutchinson considered:
(a) Polyphyletic origin of angiosperms
(b) Monophyletic origin
(c) Both (a) and (b)
(d) None of the above

214. *Pithecolobium dulce* belongs to:
(a) Cruciferae (b) Solanaceae
(c) Mimosaceae (d) Caesalpiniaceae

215. Latex is not present in:
(a) Cucurbits (b) *Hevea*
(c) *Calotropis* (d) *Euphorbia*

216. Which is wrong in respect of family Compositae (Asteraceae)?
(a) Head inflorescence (b) Hypogyny
(c) Syngenesious (d) Cypsella fruit

217. *Tagetes* belongs to family:
(a) Compositae (b) Cruciferae
(c) Malvaceae (d) Solanaceae

218. One of the following is a fibre yielding plant, which one is it?
(a) *Crotolaria juncea* (b) *Cicer arietinum*
(c) *Triticum vulgare* (d) *Impatiens balsamea*

219. A person who studies about the origin, evolution and variations in plants and also about classification of plants is referred to as:
(a) Taxonomist (b) Herbal taxonomist
(c) Classical taxonomist (d) β–taxonomist

220. Floral characters are mainly used as basis of classification in seed plants because: **(CBSE 1998; Manipal 2001)**

(a) Easy preservation of flowers
(b) Flowers are charming to work with
(c) Have variety of colours
(d) Reproductive parts are more conservative than vegetative parts

221. 'Santonin' drug is obtained from flowers of:
(a) *Aloe vera* (b) *Artemisia cina*
(c) *Atropa belladona* (d) *Colchicum autumnale*

222. A plant having bicollateral vascular bundles in its climbing stem and having unisexual flowers, will be placed in family:
(a) Cruciferae (b) Leguminosae
(c) Cucurbitaceae (d) Compositae

223. Timber is obtained from members of:
(a) Liliaceae (b) Solanaceae
(c) Leguminosae (d) Cruciferae

224. Family Compositae can be distinguished from family Solanaceae in which of the following features?
(a) Capitulum or head inflorescence
(b) Gamopetalous corolla
(c) Epipetalous stamens
(d) Bicarpellary gynaecium

*225. Only herbs are present in: **(CPMT 1992; Pb. PMT 1997)**
(a) Malvaceae (b) Cruciferae
(c) Compositae (d) Leguminosae

226. Floral formula (F.F.) does not indicate:
(a) Epipetalous and epiphyllous condition
(b) Position of ovary on thalamus
(c) Aestivation and placentation
(d) Union of stamens and carpels

227. Epipetalous stamens with free filaments but fused anthers are found in: **(CBSE 1992)**
(a) Solanaceae (b) Asteraceae
(c) Asclepiadaceae (d) Convolvulaceae

228. It is not true that: **(Re. Ex. CPMT 1992)**
(a) Underground part of some plant of Liliaceae is used as food for man
(b) Fibre yielding plants are found in Malvaceae
(c) A tree with large flowers and oil seeds is found in Compositae
(d) Many trees found in deserts having compound leaves are the members of Leguminosae

229. Floral formula of Cruciferae is: **(Re. Ex. CPMT 1992)**
(a) $K_4\,C_4\,A_5\,G_{(2)}$ (b) $K_{2+2}C_4\,A_{2+4}G_{(2)}$
(c) $K_{(5)}C_{(5)}A_5\,G_{(2)}$ (d) $K_{(5)}C_{(5)}AG_{(5)}$

230. Which of the following groups of plants produce fibres of economic importance? **(CPMT 1992)**
(a) *Gossypium, Hibiscus, Crotolaria*
(b) *Gossypium, Cassia, Lycopersicum*
(c) *Gossypium, Brassica, Glycine*
(d) *Gossypium, Agave, Nicotiana*

231. The term phylogeny means:
(a) The evolution of a genetically related group of organisms
(b) Reverse mutation
(c) Evolution of genetically distinct group
(d) None of the above

232. The fusion of petals is represented as a more highly evolved stage in:
(a) Phylogenetic system of classification
(b) Artificial system of classification
(c) Natural system of classification
(d) All of the above

233. Bessey's system of classification is based on:
(a) New ideas concerning primitive and advanced characters in plants
(b) A number of dicta or guiding principles
(c) Both (a) and (b)
(d) None of the above

234. John Hutchinson's system of classification was based on:
(a) Bentham and Hooker's system of classification
(b) Bessey's system of classification
(c) Both (a) and (b)
(d) Hallier's system of classification

235. Magnoliales and ranales are considered most primitive orders of the dicotyledons according to:
(a) Bentham and Hooker's system of classification
(b) Hutchinson's system of classification
(c) None of the above
(d) Bessey's system of classification

*236. Which of the families is considered as most advanced among monocotyledons?
(a) Orchidaceae (b) Gramineae
(c) Liliaceae (d) Ranunculaceae

237. National botanical garden of Lucknow is now known as:
(a) Royal botanic garden
(b) Indian botanic garden
(c) National botanical research institute
(d) All of the above

238. The current International code of botanical nomenclature appeared in:
(a) 1978 (b) 1982
(c) 1975 (d) 1946

239. Which of the statements regarding the six principles of International code of botanical nomenclature is correct?
(a) The application of names of taxonomic groups (taxa) is determined by means of nomenclature type
(b) The nomenclature of taxonomic group is based upon priority of publication
(c) Scientific names of taxonomic groups are treated as Latin regardless of their derivation
(d) All of the above

240. A specimen or other element selected to serve as nomenclatural type as long as all of the material on which the description of the new species was based is missing is called:
(a) Syntype (b) Neotype
(c) Isotype (d) Lectotype

241. When a specific epithet exactly repeats the generic name it is known as:

(a) Tautonyms (b) Priority
(c) Taxa (d) Neotype

242. Racemose type of branching is also known as:
(a) Cymose branching (b) Racemose branching
(c) Monopodial branching (d) Scorpioid type

243. When the main axis ceases to grow after sometimes and gives out many lateral branches is known as:
(a) Cymose branching (b) Racemose branching
(c) Both (a) and (b) (d) None of these

244. Some plants survive for two to many years but die soon after flowering and fruiting, they are known as:
(a) Monocarpic (b) Woody
(c) Biennial (d) None of these

245. Which of the following are the special types of inflorescence?
(a) Cyathium (b) Verticillaster
(c) Hypanthodium (d) All of these

246. The calyx and corolla collectively constitute the:
(a) Perianth (b) Tepal
(c) Sepal (d) Petals

247. Parietal placentation is present in:
(a) Orchids (b) Poppy
(c) Mustard (d) All of these

248. In certain unilocular ovaries placenta develops directly on the receptacle and bear a single large ovule, such a placentation is called as:
(a) Axile (b) Basal
(c) Marginal (d) Central

249. The tuft of the fine hairs formed from the calyx of each floret of Asteraceae, are attached to the fruits and aids distribution is known as:
(a) Calyculus (b) Ray florets
(c) Pappus (d) Tepal

250. A condition when the stamens are in two alternating whorls, the outer whorl is opposite to the petals is known as:
(a) Obdiplostemonous (b) Diplostemonous
(c) Epitepalous (d) None of these

251. Which of the following is not correctly matched?
(a) *Cucurbita maxima* — Tori
(b) *Cucumis sativus*— Kheera
(c) *Cucumis melo* — Melon
(d) *Citrullus vulgaris* — Watermelon

252. Rat-ki-rani which is known as *Cestrum nocturnum* belongs to family:
(a) Solanaceae (b) Rutaceae
(c) Cruciferae (d) Malvaceae

253. The capitulum consists of:
(a) Ray florets only (b) Disc florets only
(c) Both (a) and (b) (d) None of these

254. Which of the following is not correctly matched ?
(a) *Solanum tuberosum*—Onion
(b) *Solanum melongena*—Brinjal
(c) *Capsicum annuum*—Chillies
(d) *Lycopersicum esculentum* – Tomato

255. State which of the following is the second largest family of the Indian flora?
(a) Rosaceae (b) Orchidaceae
(c) Polygonaceae (d) Brassicaceae

256. The floral formula of *Allium cepa* is:
(a) $\oplus$ ⚥, P_{3+3}, A_{3+3}, $\underline{G_{(3)}}$
(b) $\oplus$, ⚥, P_{3+3}, A_{3+9}, $\underline{G_{(2)}}$
(c) $\oplus$ ⚥, K_5, C_5, A_4, $\underline{G_{(9)}}$
(d) None of the above

257. When the thalamus is convex and other floral parts are attached below the ovary it is known as .... condition:
(a) Perigynous (b) Hypogynous
(c) Epigynous (d) Gamosepalous

258. When the stamens are borne on the pistil it is known as:
(a) Gynoecium (b) Gynandrous
(c) Epipetalous (d) None of these

259. Which of the statements is correct regarding the ray florets of *Helianthus*?
(a) These are arranged along the rim of the receptacle
(b) These are generally pistillate or neuter
(c) These are zygomorphic with ligulate corolla
(d) All of the above

260. A capitulum is called the heterogamous when :
(a) There is a distinction between ray florets and disc florets
(b) There is no distinction between ray and disc floresis
(c) All the florets are bisexual
(d) All the ray florets are zygomorphic

261. Which of the following statements regarding disc florets is incorrect?
(a) They are clustered in the central disc like part of the receptacle
(b) The younger ones are near the centre and older ones towards the periphery of the disc
(c) They are usually unisexual
(d) They are usually bisexual and actinomorphic

262. Which of the following is not correctly matched?
(a) *Brassica campestris*—Mustard
(b) *Brassica nigra*—Black mustard
(c) *Brassica caulorapa*—Candytuft
(d) *Raphanus sativus*—Radish

263. The botanical name for cauliflower is: **(CBSE 1991)**
(a) *Brassica rapa*
(b) *Brassica oleracea* var. *botrytis*
(c) *Brassica oleracea*
(d) *Brassica caulorapa*

264. Which of the following statements regarding family Brassicaceae is correct?
(a) Flowers bisexual, cruciform corolla
(b) Stamens usually 6, tetradynamous
(c) Inflorescence typically racemose or corymbose raceme
(d) All of the above

265. Which of the following plants belongs to family Solanaceae?
(a) *Atropa belladona* (b) *Withania somenifera*
(c) *Nicotiana tabacum* (d) All of these

266. The floral formula of *Petunia alba* is:
(a) $\oplus\,,\ \text{⚥}\ K_{(5)}\ C_{(5)}\ A_5\ \underline{G_{(2)}}$
(b) $\oplus\ \text{⚥}\ K_{(5)}\ C_{(5)}\ A_{(5)}\ \underline{G_{(2)}}$
(c) $+\,,\ \text{⚥}\ K_{(5)}\ C_{(5)}\,,\ A_{(5)}\,,\ G_{(5)}$
(d) All of the above

267. Carolus Linnaeus was originator of:
(a) Systematic botany
(b) Sexual system of classification
(c) Both (a) and (b)
(d) None of above

268. Which of the following statements regarding Linnaeus is incorrect?
(a) He was first to use binomial nomenclature
(b) His system of classification was artificial
(c) Due to complexity of the classification it did not persist for a long time
(d) He recognised 24 classes

269. Angiosperms were distinguished into archichlamydae and metachlamydae by:
(a) Candolle (b) Cronquist
(c) Hutchinson (d) Engler and Prantl

270. Indian telegraph plant (*Desmodium gyrans*) belongs to:
(a) Malvaceae (b) Leguminosae
(c) Solanaceae (d) Liliaceae

***271.** Which of the following families is characterised by the presence of perianth ?
(a) Malvaceae (b) Liliaceae
(c) Cruciferae (d) Solanaceae

272. The botanical name of Satawar is:
(a) *Smilax* (b) *Asparagus*
(c) *Yucca* (d) *Lilium*

273. Spirocyclic (hemicyclic) numerous free stamens and apocarpous carpels are found in the family: (AMU 1995)
(a) Cruciferae (b) Cucurbitaceae
(c) Labiatae (d) Ranunculaceae

274. The floral formula:

$$\oplus\ \text{⚥}\ K_{2+2}\ C_4\ A_{2+4}\ \underline{G_{(2)}}$$

is representative of: (CBSE 1993)
(a) *Allium cepa* (b) *Helianthus annuus*
(c) *Brassica nigra* (d) *Solanum nigrum*

***275.** One aspect of flower which can be represented in floral formula but not in floral diagram is: (AMU 1996)
(a) Symmetry of flower (b) Aestivation
(c) Cohesion of floral parts (d) Position of ovary

276. Botanical name of Indian mustard (rye) is: (CPMT 1992)
(a) *Brassica campestris* (b) *B. juncea*
(c) *B. nigra* (d) *B. alba*

277. (9) + 1 condition of androecium is found in one of the families:
(a) Caesalpiniaceae (b) Papilionaceae
(c) Malvaceae (d) Rutaceae

278. Term 'New Systematics' was given by: (AFMC 2003)
(a) Julian Huxley (b) Linnaeus
(c) Darwin (d) Lamarck

279. In monocots, floral parts occur in:
(a) Two's (b) Three's
(c) Four's (d) Five's

280. Father of Indian taxonomy or systematic botany is:
(a) Linnaeus (b) H. Santapau
(c) V. Puri (d) P. Maheshwari

281. Sepals or petals which fall off very early, *i.e.*, before opening of floral bud are called:
(a) Deciduous (b) Caducous
(c) Accrescent (d) Persistent

282. Internodal elongation between corolla and androecium in a flower is known as:
(a) Gynophore (b) Androphore
(c) Anthophore (d) Androgynophore

283. A reduced or sterile stamen is called:
(a) Pistillode (b) Staminode
(c) Corona (d) Cuculus

284. In which of the following, a staminal tube surrounding ovary and style is present?
(a) *Brassica* (b) *Hibiscus*
(c) *Solanum* (d) *Allium*

285. The word ending with 'aceae' indicates:
(a) Genera (b) Family
(c) Order (d) Class

286. First great taxonomist was:
(a) Engler (b) Linnaeus
(c) Aristotle (d) Hooker

287. In Gramineae perianth is represented by small scaly lodicules which are generally:
(a) Two (b) Three
(c) Four (d) Five

288. Which of the following sets is of monocot plants?
(a) *Ranunculus* and *Anemone*
(b) *Rosa* and *Rubus*
(c) *Allium* and *Asparagus*
(d) *Calotropis* and *Coriandrum*

289. The botanical name of Toria (Lahi) is:
(a) *Brassica nigra* (b) *B. juncea*
(c) *B. napus* (d) *B. campestris*

290. A ligulate corolla found in Compositae is also known as:
(a) Masked (b) Two-lipped
(c) Strap-shaped (d) Wheel-shaped

291. In which of the following families unisexual flowers occur?
(a) Malvaceae (b) Leguminosae
(c) Cucurbitaceae (d) Cruciferae

***292.** The ovary, showing ovules borne on three parietal placentae is:
(a) Bilocular (b) Trilocular
(c) Pentalocular (d) Unilocular

293. For declaration of new species, what characters should be used?
(a) Characters of endosperm
(b) Anatomical characters of new species
(c) Physiological characters of new species
(d) Floral characters of new species

294. In Engler and Prantl's system of classification:
(a) Monocots precede dicots
(b) Dicots precede monocots
(c) Gymnosperms are in between dicots and monocots
(d) None of the above

295. First step in taxonomy is: **(AIIMS 1990)**
(a) Naming (b) Identification
(c) Description (d) Classification

296. Carrot, cashewnut, coffee, mango, mustard, potato, radish, triticales and banana represent how many families?
(a) 4 (b) 5
(c) 9 (d) 7

297. Pentamerous flowers having monoadelphous stamens and dry dehiscent fruit splitting into many mericarps belong to genus: **(CBSE 1991)**
(a) *Papaver* (b) *Coriander*
(c) *Datura* (d) *Abutilon*

298. The more significant character for identification of papilionaceous flower is: **(MDAT, Bihar 1991)**
(a) Vexillary aestivation
(b) Inferior ovary
(c) Tetradynamous condition
(d) All of the above

299. Bougainvillea flowers are variously coloured because of:
(a) Coloured bracts (b) Coloured sepals
(c) Coloured petals (d) Coloured bracteoles

Match the following : (300–307)

300. I. Carolus Linnaeus
II. Engler
III. Bentham
IV. Theophrastus
A. Swedish naturalist
B. English botanist
C. Greek naturalist
D. German botanist
(a) I–B, II–A, III–D, IV–C (b) I–B, II–D, III–C, IV–A
(c) I–A, II–D, III–B, IV–C (d) I–C, II–A, III–D, IV–B

301. I. John Hutchinson
II. Theophrastus
III. C. Linnaeus
IV. Bentham and Hooker
A. The families of flowering plants
B. Historia Plantarum
C. Systema Naturae
D. Genera Plantanum
(a) I–A, II–B, III–D, IV–C (b) I–A, II–D, III–C, IV–B
(c) I–A, II–B, III–C, IV–D (d) I–B, II–C, III–A, IV–D

302. I. Cotton
II. Saffron
III. Radish
IV. Onion
A. *Raphanus sativus*
B. *Gossypium arboreum*
C. *Allium cepa*
D. *Carthamus tinctorius*
(a) I–A, II–B, III–C, IV–D (b) I–B, II–D, III–A, IV–C
(c) I–C, II–A, III–D, IV–B (d) I–B, II–D, III–C, IV–A

303. I. Annuals
II. Biennials
III. Perennials
IV. Suffrutescent
A. Survive for two seasons
B. Complete their life cycle in one year
C. Plants having woody stem at base and herbaceous towards distal end
D. Live a long life
(a) I–B, II–A, III–D, IV– C (b) I–A, II–B, III– C, IV–D
(c) I–B, II– C, III–D, IV–A (d) I–A, II–D, III– C, IV–B

304. I. Monoadelphous stamens
II. Diadelphous stamens
III. Synandrous stamens
IV. Syngenesious stamens
A. Compositae
B. Malvaceae
C. Papilionaceae
D. Cucurbitaceae
(a) I–B, II–C, III–D, IV–A (b) I–A, II–B, III–C, IV–D
(c) I–B, II–A, III–C, IV–D (d) I–D, II–B, III–A, IV–C

305. I. Cruciform corolla
II. Butterfly-shaped corolla
III. Rosaceous corolla
IV. Bilabiate corolla
A. *Iberis*
B. Pea
C. Apple
D. *Ocimum*
(a) I–B, II–C, III–D, IV–A (b) I–A, II–B, III–C, IV–D
(c) I–A, II–B, III–D, IV–C (d) I–B, II–A, III– C, IV–D

306. I. Parietal placentation
II. Axile placentation
III. Basal placentation
IV. Superficial placentation
A. Compositae
B. Solanaceae
C. Cucurbitaceae
D. *Nymphaea*
(a) I–C, II–B, III–A, IV–D (b) I–A, II–C, III–D, IV–B
(c) I–A, II–D, III–C, IV–B (d) I–C, II–A, III–B, IV–D

307. I. Larkspur
II. Sunflower
III. Candytuft
IV. Satawar

A. *Delphinium ajacis*
B. *Helianthus annuus*
C. *Iberis amara*
D. *Asparagus officinalis*
(a) I–B, II–A, III–D, IV–C (b) I–A, II–C, III–B, IV–D
(c) I–A, II–B, III–C, IV–D (d) I–D, II–C, III–B, IV–A

308. *Dracaena* and *Yucca* (monocots with secondary growth) belong to family:
(a) Compositae (b) Liliaceae
(c) Malvaceae (d) Cruciferae

309. Which of the following is not the type of racemose inflorescence?
(a) Corymb (b) Capitulum
(c) Spike (d) Cyathium

310. In ovary, numerous ovules are present in:
(a) Gramineae (b) Solanaceae
(c) Compositae (d) None of these

311. The vexillum and keel in pea flowers constitute:
(a) Calyx (b) Corolla
(c) Androecium (d) Gynoecium

312. Phylogenetic classification is one which is based on: **(CBSE 1994)**
(a) Habit of plants
(b) Overall similarities
(c) Common evolutionary descent
(d) Utilitarian system

313. Maize plant has: **(CPMT 1994)**
(a) Male and female flowers
(b) Male or female flowers
(c) Hermaphrodite flower
(d) No flowers

314. "Taxonomy without phylogeny may be likened to bones without flesh", is a statement supported by: **(CBSE 1994)**
(a) Takhtajan (b) Bentham and Hooker
(c) Oswald Tippo (d) John Hutchinson

*315. Exceptional tetramerous flower of Liliaceae is: **(Raj. PMT 1992)**
(a) *Allium* (b) *Gloriosa*
(c) *Smilax* (d) *Aspidiastra*

316. Feathery stigma is present in: **(BHU 1995)**
(a) Wheat (b) Pea
(c) *Caesalpinia* (d) *Datura*

317. Floral formula; $\oplus$ ⚥ $K_{(5)}\,C_{(5)}\,A_{(\infty)}\,\underline{G_{(5)}}$, belongs to family: **(CPMT 1994)**
(a) Malvaceae (b) Cucurbitaceae
(c) Solanaceae (d) None of these

318. Unicarpellary hypogynous ovary is found in:
(a) *Acacia* (b) *Iberis*
(c) Onion (d) Tomato

319. Simla mirch (*Capsicum frutescens*) and potato belong to family: **(EAMCET 1990)**
(a) Solanaceae (b) Compositae
(c) Gramineae (d) Cruciferae

320. Which of these characters do not belong to Compositae? **(Re. Ex. CPMT 1991)**
(a) Ligulate ray florets (b) Basal ovules
(c) Syngenesious stamens (d) 5-lobed stigma

321. Brassicaceae (Cruciferae) can be distinguished from Malvaceae by the presence of: **(CBSE 1992)**
(a) Bicarpellary ovary in which the carpels are placed transversely and ovules are borne on parietal placentae
(b) Bicarpellary ovary in which the carpels are placed anteroposteriorly and develop replum
(c) Bicarpellary, multilocular ovary and bears ovules on parietal placentae
(d) Pentacarpellary ovary and bears ovules on axile placentae

322. Plants are mainly divided into two groups according to Bentham and Hooker, which are: **(AFMC 1993)**
(a) Dicots and monocots
(b) Gymnosperms and angiosperms
(c) Cryptogams and phanerogams
(d) Unicellular and multicellular

323. Among living organisms, the plants evolved first in the course of evolution, this is because: **(AFMC 1990)**
(a) Plant cells have simpler structure
(b) The plant cells evolved from animals.
(c) . .nimal cells evolved from plants
(d) The plants are autotrophs

324. The names of families Cruciferae and Papilionaceae are on the basis of:
(a) Calyx (b) Corolla
(c) Androecium (d) Gynaecium

325. A plant is having ascending imbricate aestivation of corolla, ten stamens in two whorls (diplostemonous condition) out of which a few are reduced to staminodes and sickle shaped style, this plant belongs to:
(a) Papilionaceae (b) Mimosaceae
(c) Caeslpiniaceae (d) Solanaceae

326. The condition of stamens, where filaments are fused but anthers are free, is called:
(a) Syngenesious (b) Adelphous
(c) Synandrous (d) Gynandrous

327. Term 'Species' was first introduced by:
(a) Aristotle (b) Linnaeus
(c) John Ray (d) A. P. de Candolle

328. 'Systematics' involves:
(a) Identification and nomenclature
(b) Identification, nomenclature and classification
(c) Identification, nomenclature, classification and phylogeny
(d) Nomenclature and classification only

329. Identification and classification of plants on the basis of only morphological characters constitute:
(a) Biosystematics (b) α-taxonomy
(c) β-taxonomy (d) New Systematics

330. Sepals or petals meeting by edges without any overlapping, constitute aestivation:
(a) Valvate (b) Quincuncial
(c) Twisted (d) Imbricate

331. Flower without perianth (naked) is called:

(a) Sepaloid (b) Lodicule

(c) Achlamydeous (d) Perigynous

332. A flower which can be divided into two equal halves by cutting in one plane only, is called: **(Raj. PMT 2001; CET J & K 2002)**

(a) Hypogynous (b) Zygomorphic

(c) Actinomorphic (d) Epigynous

333. Which one is commonly called 'gourd family'?

(a) Malvaceae (b) Compositae

(c) Ranunculaceae (d) Cucurbitaceae

334. *Physalis peruviana,* where accrescent calyx is present and whose fruits are edible, belongs to family:

(a) Solanaceae (b) Cruciferae

(c) Liliaceae (d) Compositae

335. Which one of the following plants does not belong to family Liliaceae?

(a) *Allium cepa* (b) *Asparagus officinalis*

(c) *Astragalus gummifer* (d) *Aloe vera*

336. The mode of arrangement of the leaves on the stem is called: **(CET Karnataka 1996)**

(a) Vernation (b) Phyllotaxy

(c) Aestivation (d) None of these

337. Spike of unisexual flowers is found in: **(AFMC 1996)**

(a) Bottle brush (b) Wheat

(c) Mulberry (d) *Amaranthus*

338. Sugar cane belongs to the family: **(MPPMT 1996)**

(a) Magnoliaceae (b) Palmae

(c) Cyperaceae (d) Gramineae

339. System of classification of angiosperms or plants which is based on maximum number of phenotypic attributes is: **(AIIMS 1996)**

(a) Artificial system (b) Natural system

(c) Phylogenetic system (d) None of these

340. The floral formula; $\oplus$ ⚥ $K_{2+2}\, C_4\, A_{2+4}\, \underline{G_{(2)}}$, is of: **(CBSE 1993)**

(a) *Allium cepa* (b) *Helianthus annuus*

(c) *Brassica nigra* (d) *Solanum nigrum*

341. Indian botanical garden was established by: **(AIIMS 1996, 97)**

(a) Linnaeus (b) Bentham and Hooker

(c) Brandis (d) Robert Kid

342. The complete name of a plant in binomial nomenclature has: **(MPPMT 1997)**

(a) Three parts (b) Two parts

(c) Five parts (d) One part

343. The type of specimen used by the author in original publication is known as: **(AIIMS 1996)**

(a) Lactotype (b) Isotype

(c) Holotype (d) Syntype

344. Marginal placentation is found in: **(CET Chandigarh 1997)**

(a) Leguminosae (b) Cucurbitaceae

(c) Malvaceae (d) Cruciferae

345. Binomial system of nomenclature is effective for angiosperms from: **(Pondicherry 1997)**

(a) 6.7.1736 (b) 9.6.1880

(c) 1.5.1753 (d) 5.8.1771

346. Inferior ovary with cypsella fruits are found in the family: **(CET Chandigarh 1997)**

(a) Rubiaceae (b) Cucurbitaceae

(c) Umbellifera (d) Asteraceae

347. Rutaceae differs from Malvaceae in having: **(BHU 1997)**

(a) Polypetalous corolla

(b) Simple leaves

(c) Obdiplostemonous stamens

(d) Syncarpous superior ovary

348. Cucurbitaceae has plants yielding a variety of vegetables and fruits. What is the position of this family in Bentham and Hooker classification? **(AMU 1997)**

(a) Passiflorales of calyciflorae

(b) Rosales of calyciflorae

(c) Parietales of thalamiflorae

(d) Asterales of inferae

349. Carl Linnae (Carolus Linnaeus) is from: **(Manipal 1997)**

(a) United Kingdom (b) Sweden

(c) France (d) Holland

350. Mimosaceae can be distinguished from Caesalpiniaceae on the basis of: **(BHU 1996)**

(a) Cohesion of anthers

(b) Adhesion of anthers

(c) Characters of carpels

(d) Aestivation of calyx and corolla

351. Bentham and Hooker classified dicots into: **(Pondicherry 1996)**

(a) Polypetalae, gamopetalae and glumiflorae

(b) Polypetalae, gamopetalae and monochlamydae

(c) Archichlamydae, monochlamydae and glumiflorae

(d) Archichlamydae, polypetalae and monochlamydae

352. Diadelphous androecium is found in:

(a) *Pisum* (b) *Hibiscus*

(c) *Ocimum* (d) *Brassica*

353. Find out the false statement with regard to Compositae: **(AMU 1997)**

(a) Head inflorescence (b) Hypogynous flowers

(c) Syngenesious anthers (d) Fruit is cypsela

354. Name the weed belonging to Compositae family which is a burning problem in fields in almost all states of India: **(Manipal 1997)**

(a) *Cyperus* (b) *Eichhornia*

(c) *Parthenium* (d) *Chenopodium*

355. Androecium in Malvaceae is: **(AMU 1993, 97)**

(a) Monoadelphous (b) Diadelphous

(c) Didynamous (d) Tetradynamous

356. Which can be considered equivalent to perianth? **(BHU 1992; AIIMS 1996)**

(a) Glume (b) Superior palaea

(c) Inferior palaea (d) Lodicules

357. Tetradynamous condition of androecium is one of the striking features of: **(AMU 1997; CPMT 1997; CBSE 2001; BCECE (P.T. Exam.) 2001)**

(a) Caesalpiniaceae (b) Cruciferae
(c) Papilionaceae (d) Rubiaceae

358. *Colchicum autumnale* yields colchicine which belongs to family: **(AMU 1997)**
(a) Leguminosae (b) Cucurbitaceae
(c) Liliaceae (d) Cruciferae

359. Atropine used for dilation of eye pupil is obtained from the plant species of family: **(AIIMS 1996)**
(a) Ranunculaceae (b) Cruciferae
(c) Liliaceae (d) Solanaceae

360. The herbarium specimen preserved in the Indian national herbarium at Howrah, West Bengal have been arranged according to system of classification of: **(AMU 1996; Raj. PMT 2001)**
(a) Bentham and Hooker (b) Engler and Prantl
(c) Hutchinson (d) Takhtajan

361. The floral formula of Compositae is: **(AFMC 1997)**
(a) $\oplus$ ⚥ $K_5C_5A_5\underline{G_{(2)}}$
(b) % ⚥ $K_5C_6A_5G_{(2)}$
(c) $\oplus$ or % ♀ or ⚥ K-pappus $C_{(5)}\ A_5\overline{G_{(2)}}$
(d) $\oplus$ ♀ $K_{2+2}C_4A_{2+4}\underline{G_{(2)}}$

362. Bicarpellary syncarous, superior, bilocular ovary, oblique position of ovary, oblique septum and swollen placenta are characteristic features of gynoecium of: **(Pb. PMT 1997)**
(a) Potato (b) *Ranunculus*
(c) *Cucurbita* (d) Mustard

363. A taxon with reference to classification of organisms can be defined as: **(CBSE 1996, 97)**
(a) A group of similar genera
(b) A group of similar species
(c) A group of organisms based on chromosome numbers
(d) A group of any one rank of organisms

***364.** Which of the plant groups has evolved most recently? **(AMU 1997)**
(a) Conifers (b) Gymnosperms
(c) Grasses (d) Mosses

365. Unbranched stem with persistent leaf bases are found in members of: **(AMU 1997)**
(a) Myrtaceae (b) Apocynaceae
(c) Solanaceae (d) Arecaceae

366. Lathyrism which is caused by consumption of Khesari dal is a disease characterised by: **(CBSE 1998)**
(a) Gross skeletal deformation and thinning of collagen fibres and fibrils
(b) Reproductive failure, susceptibility to diabetes mellitus and skeletal abnormalities
(c) Retardation of body growth, precocious puberty and renal disfunction
(d) Mental retardation, delay in the onset of puberty and cardiovascular abnormalities

367. Replum is found in: **(CPMT 1998; Raj. PMT 2002)**
(a) Cruciferae (b) Leguminosae
(c) Compositae (d) Solanaceae

368. Diadelphous condition is in: **(CPMT 1998)**
(a) Cruciferae (b) Papilionaceae
(c) Malvaceae (d) Compositae

369. Weed of family Compositae is: **(CPMT 1998)**
(a) Congress grass
(b) *Argemone mexicana*
(c) *Chenopodium ambrosoides*
(d) *Eichhornia*

370. Bicollateral vascular bundles are found in: **(CPMT 1998)**
(a) Cruciferae (b) Cucurbitaceae
(c) Leguminosae (d) Mimosoidae

371. Unisexual flowers are present in: **(BHU 1999)**
(a) Solanaceae (b) Liliaceae
(c) Cucurbitaceae (d) All of these

372. Lady's finger is the member of: **(BHU 1999)**
(a) Solanaceae (b) Malvaceae
(c) Cruciferae (d) Compositae

373. Which is correctly matched? **(CBSE 2000)**
(a) Orange—Cucurbitaceae (b) Mango—Compositae
(c) Wheat—Brassicaceae (d) Cotton—Malvaceae

***374.** The hairs present on the maize cob are: **(CBSE 2000)**
(a) Modified bract hairs (b) Seed hairs
(c) Anthers (d) Styles

375. Plants which yield pulses belong to family: **(MPPMT 2000)**
(a) Papilionaceae (b) Rosaceae
(c) Malvaceae (d) Compositae

376. The genus *Euphorbia* has:
(a) Spike (b) Thyrsus
(c) Catkin (d) Cyathium

377. Match the names of plants given under column–I with the families to which they belong given under column–II. Choose the answer which gives the correct combination of the alphabets: **(CET Karnataka 2000)**

	Column–I (Plant names)		**Column–II (Family names)**
A	*Nerium indicum*	p	Arecaceae
B	*Cassia fistula*	q	Solanaceae
C	*Caryota urens*	r	Liliaceae
D	*Nicotiana tabacum*	s	Apocynaceae
		t	Caesalpiniaceae

(a) A = s, B = t, C = p, D = q
(b) A = s, B = t, C = q, D = p
(c) A = t, B = s, C = q, D = p
(d) A = s, B = p, C = t, D = q

378. Feathry stigma is present in: **(BHU 2000)**
(a) Wheat (b) Pea
(c) *Caesalpinia* (d) *Datura*

379. Floral formula + ⚥ $K_5\ C_5\ A_{5+5}\ \underline{G_1}$ is characteristic of family: **(BHU 2000)**
(a) Papilionaceae (b) Caesalpinioideae
(c) Cruciferae (d) Mimosoideae

380. The floral formula of family Liliaceae is: (BHU 2000)
(a) ⊕⚥ $P_{3+3}\ A_{3+3}\ \underline{G_{(3)}}$ (b) ⊕⚥ $P_6A_6G_3$
(c) +⚥ $P_6A_6G_3$ (d) +⚥ $P_{3+3}\ A_{3+3}\ \underline{G_{(3)}}$

381. Which of the following plants has a corolla with 4 petals? (Manipal 2001)
(a) Shoe-flower (b) China rose
(c) Pea plant (d) Mustard

382. Which of the following plants has (9) + 1 arrangement of stamens? (Manipal 2001; AIIMS 2001)
(a) Mustard (b) Pea
(c) Lily (d) China rose

383. The correct sequence of taxonomic categories is: (AFMC 2001)
(a) Class-phylum-tribe-order-family-genus-species
(b) Phylum-order-class-tribe-family-genus-species
(c) Division-class-family-tribe-order-genus-species
(d) Division-class-order-family-tribe-genus-species

384. The example of polypetalous zygomorphic corolla is:
(a) *Crotolaria* (b) *Ocimum*
(c) Mustard (d) Rose

*385. Ratio of female : male flowers is 1 : ∞ in: (CPMT 2001)
(a) Hypanthodium (b) Cyathium
(c) Both (a) and (b) (d) None of these

386. Tricarpellary syncarpous gynaecium with inferior ovary is characteristic of: (CPMT 2001)
(a) Solanaceae (b) Compositae
(c) Liliaceae (d) Cucurbitaceae

387. Family Cruciferae is also known as: (BHU 2001)
(a) Siliquaceae (b) Tetradynamaceae
(c) Brassicaceae (d) Raphananceae

388. Gram belongs to the family: (MPPMT 2001)
(a) Gramineae (b) Papilionaceae
(c) Compositae (d) Solanaceae

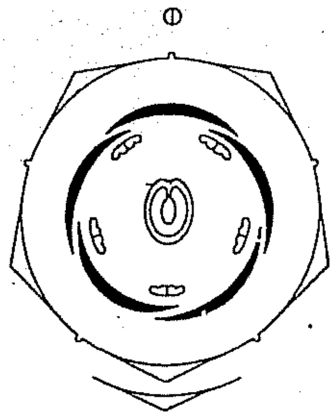
389. Cotton plant belongs to family: (MPPMT 2001)
(a) Cruciferae (b) Leguminosae
(c) Malvaceae (d) Euphorbiaceae

390. Inflorescence with universal sessile flowers is: (CET J & K 2002)
(a) Spike (b) Spikelet
(c) Catkin (d) Spadix

391. The flower in Fabaceae is: (JIPMER 2002)
(a) Complete, zygomorphic, pentamerous
(b) Complete, actinomorphic trimerous
(c) Incomplete, zygomorphic, trimerous
(d) Incomplete, actinomorphic, pentamerous

392. The ovary which shows basal placentation is: (JIPMER 2002)
(a) Monocarpellary, bilocular
(b) Bicarpellary, syncarpous and unilocular
(c) Multicarpellary, syncarpous and unilocular
(d) Syncarpous having two or more carpels

393. Choose the correct description of the flower depicted in the floral diagram given ahead: (CET Karnataka 2002)



(a) United, valvate sepals; free, imbricate petals; epipetalous stamens; unilocular ovary with marginal placenta
(b) United, valvate sepals; free, imbricate petals; free stamens; unilocular ovary with marginal placenta
(c) United, valvate sepals; free, twisted petals; free stamens; unilocular ovary with marginal placenta
(d) United, valvate sepals; free, imbricate petals; free stamens; unilocular ovary with axile placenta

394. A flower characterized by monoadelphous, tubular androecium belongs to: (BCECE 2002)
(a) Solanaceae (b) Liliaceae
(c) Malvaceae (d) Brassicaceae

395. A member of compositae family which gives oil is: (Raj. PMT 2001)
(a) *Glycine max* (b) *Carthamus tinctorius*
(c) *Brassica tulipa* (d) *Morus alba*

396. Four sepals K_4 or (2 + 2) is the characteristic feature of the family: (BHU 2002)
(a) Solanaceae (b) Malvaceae
(c) Papilionaceae (d) Brassicaceae

397. The chief anatomical feature of the family cruciferae is the presence of: (BHU 2002)
(a) Latex (b) Pectin
(c) Alkaloids (d) Myrosin enzyme

398. Which of the following fruits is/are found in the family Ranunculaceae? (BHU 2002)
(a) Berry (b) Capsule
(c) Achenes (d) All of these

399. Verticillaster inflorescence is found in: (Haryana PMT 2001)
(a) Labiatae (b) Cruciferae
(c) Compositae (d) Solanaceae

400. Inferior ovary is found in: (VVMC Safdarjung 2001)
(a) Labiatae (b) Liliaceae
(c) Solanaceae (d) Compositae

401. Kew is a well known: (MGIMS Wardha 2001)
(a) Plant herbarium (b) Botanical laboratory
(c) Botanical garden (d) Botanical park

402. In which of the following aestivation sepal's/petal's one margin covers the other and its margin is covered by previous one? **(Raj. PMT 2002)**
(a) Valvate (b) Twisted
(c) Imbricate (d) Quincuntial

403. In the flowers of fabaceae one of the following immediately encloses the essential organs? **(EAMCET 2002)**
(a) Anterior petals (b) Posterior petals
(c) Lateral petals (d) Sepals

404. In Bentham and Hooker's classification the way of arrangement of the three series of polypetalae refects gradual evolution of flower from: **(EAMCET 2002)**
(a) Dichlamydeous to monochlamydeous condition
(b) Apocarpy to syncarpy
(c) Hypogyny to epigyny
(d) Bisexuality to unisexuality

405. In cyathium inflorescence the ratio between male and female flowers is: **(EAMCET 2002)**
(a) One : many (b) Many : one
(c) One : one (d) One : two

406. Night Queen and Day King belong to one of the following genera: **(EAMCET 2002)**
(a) *Sesbania* (b) *Chrysanthemum*
(c) *Cestrum* (d) *Lilium*

407. The economically important plant of family Malvaceae is: **(Raj. PMT 2002)**
(a) *Gossypium hirsutum* (b) *Hibiscus canabinus*
(c) *Abelmosclus esculentus* (d) All of these

408. In gramineae the inflorescence is a: **(Orissa JEE 2003)**
(a) Spadix (b) Spikelet
(c) Panicle (d) Cyathium

409. Phylogenetic system of classification is proposed by: **(Orissa JEE 2003)**
(a) John Hutchinson (b) Carolus Linnaeus
(c) George Bentham (d) J.D. Hooker

410. The concept that monocots are more primitive than dicots was proposed by: **(Kerala PMT 2003)**
(a) Bentham and Hooker (b) Theophrastus
(c) Aristotle (d) Bessey
(e) Engler and Prantl

411. Identify the monocarpic palm: **(Kerala PMT 2003)**
(a) *Areca* (b) *Borassus*
(c) *Calamus* (d) *Corypha*
(e) *Elaeis*

412. Species are considered as: **(CBSE 2003)**
(a) Units of variety
(b) Real units of taxonomy
(c) The highest units of taxonomy
(d) Real basic units of classification

413. Linnaeus system of plant classification is: **(PMET Punjab 2003)**
(a) Natural (b) Artificial
(c) Phylogenetic (d) Unsymmetrical

414. Holy basil (Tulsi) is member of family: **(Manipal 2003)**
(a) Umbelliferae (b) Asclepiadaceae
(c) Labiatae (d) None of these

415. The place for keeping and studying dry plants is called: **(MGIMS Wardha 2003)**
(a) Arboreum (b) Vasculum
(c) Herbarium (d) Museum

416. Glumes of Jowar plant are called: **(MGIMS Wardha 2003)**
(a) Palea (b) Lemma
(c) Lodicules (d) Spikelets

417. Scientific name of family ends with: **(MGIMS Wardha 2003)**
(a) ales (b) sida
(c) lae (d) ata

418. Which family of angiosperm (dicots) has only bisexual flowers (rarely unisexual): **(CMC Vellore 2003)**
(a) Cucurbits (b) Euphorbias
(c) Asteraceae (d) Malvaceae

419. The condition in which stamens are fused with the carpels is called: **(CMC Vellore 2003)**
(a) Epipetalous (b) Synandrous
(c) Syngenesis (d) Gynandrous

420. Corymb inflorescence is only related to: **(CMC Vellore 2003)**
(a) Umbel (b) Capitulum
(c) Hypanthodium (d) Cyathium

ANSWERS

1—b	2—b	3—d	4—a	5—c	6—d	7—b	8—d	9—a	10—b	11—c	12—c
13—c	14—a	15—c	16—a	17—b	18—c	19—a	20—b	21—d	22—a	23—c	24—c
25—c	26—d	27—c	28—b	29—b	30—c	31—b	32—a	33—a	34—b	35—b	36—b
37—b	38—c	39—a	40—c	41—b	42—c	43—c	44—a	45—c	46—a	47—d	48—c
49—d	50—a	51—c	52—c	53—c	54—d	55—d	56—b	57—c	58—b	59—c	60—a
61—a	62—c	63—c	64—d	65—b	66—a	67—b	68—a	69—b	70—a	71—c	72—c
73—c	74—c	75—b	76—a	77—b	78—c	79—a	80—b	81—c	82—a	83—b	84—d
85—c	86—c	87—a	88—c	89—c	90—b	91—d	92—b	93—a	94—a	95—b	96—c
97—b	98—c	99—a	100—d	101—b	102—d	103—b	104—c	105—c	106—a	107—b	108—c
109—d	110—c	111—d	112—c	113—d	114—b	115—d	116—a	117—c	118—b	119—b	120—a
121—c	122—c	123—c	124—b	125—c	126—b	127—b	128—b	129—b	130—c	131—c	132—c
133—c	134—d	135—d	136—a	137—b	138—b	139—b	140—c	141—b	142—c	143—d	144—d
145—b	146—c	147—b	148—d	149—c	150—b	151—b	152—c	153—a	154—b	155—d	156—d
157—a	158—d	159—b	160—a	161—c	162—b	163—c	164—c	165—d	166—c	167—c	168—c
169—c	170—d	171—c	172—c	173—b	174—a	175—b	176—a	177—a	178—d	179—c	180—d
181—b	182—d	183—b	184—b	185—b	186—b	187—a	188—c	189—c	190—b	191—b	192—b
193—c	194—b	195—d	196—d	197—d	198—b	199—b	200—a	201—a	202—c	203—a	204—c
205—b	206—b	207—c	208—a	209—b	210—d	211—a	212—b	213—b	214—c	215—a	216—b
217—a	218—a	219—c	220—d	221—b	222—c	223—c	224—a	225—b	226—b	227—b	228—c
229—b	230—a	231—a	232—a	233—c	234—c	235—b	236—b	237—c	238—a	239—d	240—b
241—a	242—c	243—a	244—a	245—d	246—a	247—d	248—b	249—c	250—a	251—a	252—a
253—c	254—a	255—b	256—a	257—b	258—b	259—d	260—a	261—c	262—c	263—b	264—d
265—d	266—a	267—b	268—c	269—d	270—b	271—b	272—b	273—d	274—c	275—d	276—b
277—b	278—a	279—b	280—b	281—b	282—b	283—b	284—b	285—b	286—b	287—a	288—c
289—c	290—c	291—c	292—d	293—d	294—a	295—b	296—d	297—d	298—a	299—a	300—c
301—c	302—b	303—a	304—a	305—b	306—a	307—c	308—b	309—d	310—b	311—b	312—c
313—a	314—a	315—d	316—a	317—a	318—a	319—a	320—d	321—a	322—b	323—d	324—b
325—c	326—b	327—c	328—c	329—b	330—a	331—c	332—b	333—d	334—a	335—c	336—b
337—c	338—d	339—b	340—c	341—d	342—b	343—c	344—a	345—c	346—d	347—c	348—a
349—b	350—d	351—b	352—a	353—b	354—c	355—a	356—d	357—b	358—c	359—d	360—a
361—c	362—a	363—d	364—c	365—d	366—a	367—a	368—b	369—a	370—b	371—c	372—b
373—d	374—d	375—a	376—d	377—a	378—a	379—b	380—a	381—d	382—b	383—d	384—a
385—b	386—d	387—c	388—b	389—c	390—a	391—a	392—b	393—b	394—c	395—b	396—d
397—d	398—d	399—a	400—d	401—a	402—b	403—a	404—c	405—b	406—c	407—d	408—b
409—a	410—c	411—c	412—d	413—b	414—c	415—a	416—b	417—c	418—d	419—c	420—a

EXPLANATION OF SELECTED QUESTIONS (*)

21. Plant flowering once in its life is called monocarpic, *e.g.*, Bamboo.

50. Linnaeus considered species as a fixed and immutable entity or static entity.

113. Geocarpic or below ground fruits are produced in groundnut (*Arachis hypogea*).

121. In flowers of monocots, the flower parts in 3's or multiples of 3's, *i.e.*, trimerous.

132. Family Magnoliaceae (in woody plants) and Ranunculaceae (in herbaceous plants) are considered to be most primitive families according to John Hutchinson.

149. Symmetry of flower is represented by both floral diagram and floral formula.

153. *Cajanus cajan* (Arhar) is leguminous plant having root nodules, hence can grow in nitrogen deficient soils.

225. The members of family cruciferae are annual or perennial herbs.

236. Family Gramineae (Poaceae) is most advanced family of monocotyledons.

271. Perianth is characteristic of monocots as in family Liliaceae.

275. Position of ovary (superior or inferior) can be represented only in floral formula and not in floral diagram.

292. Ovary with parietal placentation is always unilocular.

315. *Aspidiastra* in family Liliaceae is having tetramerous flower (not trimerous).

364. Grasses (Gramineae) are most advanced among angiosperms.

374. Silky hairs in maize cob are long styles.

385. In cyathium inflorescence, single central terminal female flower bears number of male flowers at its base.

[illegible]

Economic Botany

20

Plants and Human Welfare

- Introduction
- Food plants—Cereals, Millets, Pseudocereals, Pulses, Nuts, Vegetables, Fruits
- Woods
- Cork
- Rubber
- Fibres
- Tannins
- Dyes
- Sugars
- Starch
- Fumitories and Masticatories
- Non-alcoholic beverages
- Spices and Condiments
- Essential oils
- Fatty oils
- Medicinal plants
- Paper
- Old World and New World crops

The three basic necessities of life, *i.e.*, food, clothing and shelter are fulfilled by plants.

The branch of botany which deals with application of knowledge of botany for the welfare of human beings is known as Economic botany.

FOOD PLANTS

(A) Cereals

Most important source of food in the world are cereals. These are members of family Poaceae or Gramineae, which are having a characteristic fruit called **'Karyopsis'** or **'Grain'**. (Karyopsis or grain is one seeded indehiscent fruit in which seed coat fuses with ovary wall or fruit wall to form husk.)

The name cereal has been given after the name of Roman Goddess **'Ceres'** who is considered to be giver of grains. These cereals wheat, barley, etc., are thus called **'Cerealia munera'** or **'Gifts of Ceres'**.

Cereals are the rich source of **carbohydrates**, present in **endosperm** which is the edible portion in cereals.

There are six true cereals, namely:

(i) Rice : *Oryza sativa*

Most important source of food in world is rice.

- It occupies largest area under cultivation in India (about 79 million acres).
- **India and China** are considered to be centre of origin of rice, *i.e.*, old world crop.

Rice is the principal cereal of tropics. A.P., Assam, Bihar, M.P., Maharashtra, Tamilnadu and West Bengal are the main rice growing states in India. Rice is sown in June and July in nurseries and then transplanted in field. Blue green algae and green manure crops are responsible for encouraging yield of rice.

Important varieties of rice are, **IR-36, IR-8, IR-20, Jaya, Ratna, Pankaj, Rasi, Akashi, Pusa–33, Padma, Jagannath, Krishna, Kaveri, Bhawani, Sona, Basmati-217, Basmati-370, Jayanti,** etc.

- ○ Maximum carbohydrate content (73–82%) occurs in rice.

Rice serves good food with pulses. Its flour is used in pastries, puddings, ice-creams, etc. Rice bran oil is used in preparing soap and cosmetics. In laundering and preparation of adhesive, rice starch is used.

- ○ Important beverage 'Sake' of Japan is obtained by fermenting rice.

(ii) Wheat : *Triticum aestivum*

Wheat is world's most widely cultivated food crop.

It is **second staple crop** of India and is most important cereal crop of temperate region.

- USA is the largest wheat producing country in the world, while in India the area under wheat cultivation is about 29 million acres.
- Wheat is a native of West Asia.

- U.P., Punjab, M.P., Maharashtra, Bihar and Rajasthan are the chief wheat growing states of India. Wheat is a **Rabi crop**, *i.e.*, sown in October and November.

Important varieties of wheat are, Lerma Rojo, Sonora-64, **Sonalika, Arjun, Hira, Janak, WH-147, HD-2204, HD-2189, HP-1209, UP-115, C-306, KSML-3, NP-818, NP-836**, etc.

- In wheat carbohydrate content is **65–74%**.
- The flour of wheat is used for various purposes. The straw is used as fodder.
- Corrugated paper is made from wheat straw.

(iii) Maize : *Zea mays*

Maize is largest among cereals, attaining a height of 3–15 ft. It is a native of **Central America** (*i.e.*, new world crop). Maize, in India is grown as a **Kharif crop**, *i.e.*, sown in June–July.

The important varieties of maize are, **Ganga Safed–2, Ganga-5, Him-123, Deccan-101, Vijay, Ganga-9, Histarch, Jawahar, VL-54, Amber, Deccan**, etc.

- The maize grains contain carbohydrates 66%, proteins, 10–12% and fats.

Maize grains are used in making corn flakes, popcorns, etc. Its flour is also used for making chapatis. Corn oil is used in soap making, cosmetics, etc.

- Artificial woolly fibres with good tensile strength are obtained from **'Zein'** protein of maize.

(iv) Barley : *Hordeum vulgare* (Jau)

Barley was first cereal to be domesticated.

It is a **Rabi crop.**

Barley is used for making **malt**, whisky and other alcoholic beverages. Its flour is used for making chapatis.

(v) Oat : *Avena sativa* (Javi)

Oats are the **most nutritious** among all cereals because of their high fat, protein and mineral contents.

- United States leads the world in production of oats.
- Oats are thought to be having multiple origin.
- Oat meal is used mainly in cakes biscuits, etc. It is not good for preparing breads because **gluten** content is absent in grains.

(vi) European rye : *Secale cereale*

Rye is of more **recent origin** as compared to other cereals. It is probably a native of Black and Caspian Seas region of Central Eurasia.

- Rye is chiefly produced and used in Europe.

It is mainly used in preparing bread as the grain contains gluten.

- Rye bread is known as **Schwartzbrot** or **black bread**, because of its dark colour.

Triticale (first man made cereal or crop)

Triticale (Triticosecale) is a **man made cereal** produced by intergeneric hybridization between **wheat** (*Triticum* sps.) and **European rye** (*Secale cereale*), *i.e.*,

Triticum × *Secale cereale* ⟶ *Triticosecale* or *Triticale*

- It is like wheat but grains are shrievelled.

(B) Millets

Small sized grains are known as millets.

- The edible portion in millets is **endosperm**. Some of the important millets are:

(i) Sorghum : *Sorghum vulgare* (Jawar)

- Centre of origin of *Sorghum* is Asia and Africa. It is a staple food for millions of people in these continents.

Sorghum is used in various ways, *i.e.*, in preparation of paper, brushes, etc. It is also used as fodder.

(ii) Pearl millet : *Pennisetum typhoides* (Bajra)

- Centre of origin of Pearl millet is Africa and is the most important Indian millet.
- Pearl millet can be grown in both **Kharif** as well as Rabi seasons. It can grow well in the regions of less rainfall (**dry farming crop**).

Pearl millet is used as food by poor people. Its flour is used in making chapatis. The plant is also used as forage.

(iii) Finger millet : *Eleusine coracana* **(Ragi, Mandua)**

- Finger millet is also known as **African millet** or **korakan.**

Finger millet is most suitable for **dry farming.** It can survive in severe drought and is also pest and disease resistant. The grains of finger millet can survive upto **50 yrs** without any damage.

- Finger millet is a **Kharif crop.**
- Its flour is used for making chapatis by poor people and plant is used as forage.
- Finger millet is used in preparation of **infant food.**

(iv) Proso millet : *Panicum miliaceum*

It is also called **true millet** or **broom corn millet** or **Russian millet** or **Indian millet** or **hog millet.**

- The centre of origin of Proso millet was most probably **India or eastern mediterranean region.**
- The grains of Proso millet contains good amount of carbohydrates, proteins and fat.
- Proso millet is used as hog feed and bread can also be made.

(v) Foxtail millet : *Setaria italica*

Foxtail millet is also known as **Italian** or **German** or **Siberian** or **Hungarian millet.**

- Centre of origin probably was **Eastern Asia.**
- Foxtail millet is used for food and plant is used as fodder.

(C) Pseudocereals

Sometimes seeds of other plants are used like cereals and millets as source of food, although they are **not grasses.** These seeds are known as **pseudocereals.** There are two widely used pseudocereals:

(i) Buck wheat : *Fagopyrum sagittatum* or *F. esculentum* **(Kuttu).**

It belongs to family **Polygonaceae.**

Buck wheat is a native of **Central Asia.** The seeds of buck wheat are ground and flour is used for **porridge, pancakes,** etc.

o Buck wheat is a source of a glucoside, **rutin** which is used in the treatment of hypertension and high blood pressure.

(ii) Gorgannut : *Euryale ferox* (Makhana)

It belongs to family Nymphaeaceae. These are roasted and eaten. It is very light food with milk.

(D) Pulses

Pulses are next to cereals as source of human food. They belong to family **Leguminosae** which has a characteristic fruit called a **legume or pod.**

- Pulses are rich source of proteins besides carbohydrates, fats, minerals and vitamins. Proteins occur as **aleurone grains.** This high protein content is due to the presence of root nodules in legumes.
- In India $\frac{1}{7}$th of total cultivated land is under pulse cultivation.

Some of the important pulses are as follows:

(i) Gram or Chick pea or Bengal gram : *Cicer arietinum.*

- It is a native of Southern Europe.

In India 37% of land under pulse cultivation belongs to gram.

- Gram is a dry farming crop.

It is used in various purposes. The roasted seeds are highly nutritious. Its flour known as besan is used in preparation of various dishes.

(ii) Pigeon pea or Red gram or Arhar : *Cajanus cajan*

- It is probably a native of Africa.

Pigeon pea is grown as a mixed crop.

The dry seeds are used as dal.

- **Urease enzyme is obtained from arhar which is used in estimation of urea in urine and blood.**

(iii) Soybean : *Glycine max*

- It is a native of South-Eastern Asia.
- Maximum protein content (32–48%) is found in soybean.

Soybean seeds when green or dry are used for various purposes. Soya milk is highly nutritious and used for infants. Its flour serves an excellent food for **diabetics** because of its high protein and low carbohydrate content.

(iv) Pea : *Pisum sativum.*

- It is a native of Southern Europe.

It is a winter crop and grown all over India. The green seeds of pea are used as vegetable.

مونگ پھلی

(v) Groundnut or Peanut : *Arachis hypogea*

- It is a native of Brazil.

In India it is mainly grown in **Gujarat** and **Rajasthan.**

Groundnuts are very nutritious because of high protein content.(one lb. of peanuts yield 2700 cal.)

o **Ardil protein** is obtained from peanuts which is used in manufacturing fibres.

Groundnut oil is used in cooking.

(vi) Hyacinth bean : *Dolichos lablab*

It is cultivated throughout India. The pods are used as vegetable.

(vii) Jack bean or Sword bean : *Canavalia gladiata*

Jack bean is a cover crop. The green pods are used as vegetables.

(viii) Moth bean : *Phaseolus aconitifolius*

The seeds are used as 'dal' which are a good source of protein. The plants are used as fodder.

(ix) French bean or Kidney bean or Garden bean or Vilayati sem : *Phaseolus vulgaris*

This is native of America. Being a good source of protein, French bean is used in various ways for human consumption.

(x) Broad bean or Windsor bean : *Vicia faba*

It probably originated in south-west Asia. Young pods are eaten as vegetable. Broad bean is used in Europe since ancient times.

(xi) Black gram or Urd : *Phaseolus mungo;* Syn. *Vigna mungo*

It is a good source of proteins. The seeds of black gram are used as 'dal'.

(xii) Green gram or Moong : *Phaseolus aureus;* Syn. *Vigna radiata*

The dried seeds are used whole or after splitting in the form of dal. The green pods are also eaten as vegetable.

(xiii) Horse gram : *Dolichos biflorous*

(xiv) Lentil : *Lens culinaris*

- It is a native of south-west Asia. It is used from ancient times. The seeds are used as 'dal'.

(xv) Cow pea : *Vigna sinensis*

It is cultivated throughout India. When young the pods are eaten as vegetable and seeds are used as pulse.

Some other important legumes

Tree legume : *Prosopis juliflora*

It is also called Algaroba or Mesquite or Keawe. Its flowers are source of honey and pods are used as cattle feed.

Rotenone : It is a white crystalline substance obtained from dry roots of *Derris* and *Lonchocarpus* (members of family Leguminose).

Rotenone is used in **fish poisoning** and as **insecticide.**

(E) Nuts

A nut is a single celled, single seeded dry fruit with hard pericarp.

These have **high protein and fat contents besides starch, sugar and mineral elements.**

Depending upon the type of content which they contain, nuts are divided into three categories–

(I) Nuts with high protein content
(II) Nuts with high carbohydrate content
(III) Nuts with high fat content.

(I) Nuts with high protein content

(i) Almonds (Badam): *Prunus amygdalus*; Fam.—Rosaceae

(ii) Green almond (Pista) : *Pistacia vera;* Fam.— Anacardiaceae

(iii) Beech nuts : *Fagus sylvatica;* Fam.—Fagaceae

(II) Nuts with high carbohydrate content

(i) Chestnut : *Castanea sativa;* Fam.—Fagaceae

It is a truenut.

(III) Nuts with high fat content

(i) Coconut (Nariyal) : *Cocos nucifera;* Fam.–Palmae

It is commonly known as **'Kalpavriksha'** because a number of useful products are obtained from it.

- Chiefly grown in Kerala (in Malayalam or Sanskrit, 'Keralam' means land of coconuts).

Nearly all parts of these nuts are used. These provide a nutritious, refreshing juice. The soft kernels are scraped and eaten. The mature nuts provide **copra** (endosperm) which is used in various ways. Coconut oil is obtained from the copra.

Fibrous mesocarp provides **coir.** The dry leaves are used for temporary sheds.

(ii) Cashewnut (Kaju) : *Anacardium occidentale;* Fam.—Anacardiaceae

- It is native of **Brazil.**

Most conspicuous product of the tree is 'false fruit' which is a swollen peduncle, known as **cashew apple** and is the receptacle for the true fruit.

(iii) **English walnut** (Akhrot) : *Juglans regia;* Fam.—**Juglandaceae**

It is native of **Iran.**

The edible portion is the **kernels** which are the cotyledons of the seed.

(iv) Pinenut (Chilgoza) : *Pinus gerardiana;* Fam.—*Pinaceae*

The edible seeds are tasty, nutritious having a delicious flavour.

(F) Vegetables

The term vegetable has been given to those edible plants which store reserve food in their roots, leaves, stem or fruits. Vegetables are eaten **after cooking, raw or as salad.**

In balanced diet daily requirement of vegetable per adult per day is ten ounces (250 g) which can be fulfilled by eating 80–85 g of root vegetables and rest leafy vegetables.

Depending upon the parts, where the food is stored, the vegetables are divided into **three categories**–

(I) Underground vegetables
(II) Herbage vegetables
(III) Fruit vegetables.

(I) Underground vegetables

As the name indicates, food is stored in the underground parts. These parts may be **roots** or **underground stems.**

(a) Root vegetables

(i) **Sweet potato** (Shakarkand or Mitha alu) : *Ipomea batatus;* Fam.—**Convolvulaceae**

It is native of **tropical America.**

(ii) Tapioca (Shakarkanda) : *Manihot esculenta;* Fam.—Euphorbiaceae

It is native of South America.

(iii) Yams (Khamalu) : *Dioscorea alata;* Fam.—Dioscoreaceae

They possess large storage roots.

(iv) Beet root (Chukandar) : *Beta vulgaris;* Fam.—**Chenopodiaceae**

It is the **second important source of sugar in world. The presence of sugar in the roots was first noted in 1590 by Maregraf.**

(v) Radish (Muli) : *Raphanus sativus;* **Fam.—Cruciferae**

(vi) Turnip (Shalgam) : *Brassica rapa;* Fam.—Cruciferae

(vii) Carrot (Gajar) : *Daucus carota;* Fam.—Umbelliferae

(b) Underground stem vegetables

(i) **Potato** (Alu) : *Solanum tuberosum* ; Fam.—**Solanaceae**

It is native of America (new world crop). Potato is most important tuber crop in world.

Important varieties of potato are: **Kufri Alankar, Kufri Jyoti, Kufri Sheetman, Kufri Lalima, Darjeeling Red Round, Gola, Phulwa,** etc.

اروی (ii) Taro (Arvi or Ghuiyan) : *Colocasia esculenta;* Fam.—Araceae

(iii) Jerusalem Artichoke (Hathichuk) : *Helianthus tuberosus;* Fam.—**Compositae**

(iv) **Onion** (Piyaz) : *Allium cepa;* **Fam.—Amaryllidaceae**

Onion is tunicated bulb and store reserve food in its scaly leaves. It has a **pungent** taste which is due to presence of an **acrid oil, allyl sulphide.** Fresh juice of onion has **bactericidal properties.**

(v) Garlic (Lahsun) : *Allium sativum;* **Fam.—Amaryllidaceae**

It is an **imbricate bulb.**

Garlic is good for **heart patients** and **reduces blood cholestrol.** Its powder serves as **carminative** and **gastric stimulant.**

(vi) White Lotus (Kamal kakri) : *Nymphaea nouchali;* **Fam.—Nymphaeaceae**

(II) Herbage vegetables

(i) Cabbage (Band gobhi) : *Brassica oleracea* var. *capitata;* Fam.—**Cruciferae**

In cabbage younger leaves are surrounded by older leaves, which are eaten.

(ii) **Cauliflower** (Phool gobhi) : *Brassica oleracea* var. *botrytis;* Fam.—**Cruciferae**

The condensed inflorescence is eaten as vegetable.

(iii) Kohlrabi (Ganth gobhi) : *Brassica oleracea* var. *gongylodes;* Fam.—Cruciferae

Condensed stem is eaten as vegetable.

(iv) **Spinach** (Palak) : *Spinacia oleracea;* Fam.—**Chenopodiaceae**

It is native of **South-Western Asia.**

Spinach is rich source of Iron and minerals.

(v) Pig weed (Bathua): *Chenopodium album;* Fam.—Chenopodiaceae

(vi) Fenugreek (Methi): *Trigonella foenum-graecum;* Fam.—Papilionaceae

(vii) Amaranth (Chulai): *Amaranthus blitum;* Fam.—Amaranthaceae

(III) Fruit vegetables

(i) Tomato: *Lycopersicum esculentum;* Fam.—Solanaceae

(ii) Brinjal or Egg plant: *Solanum melongena;* Fam.—Solanaceae

(iii) Cucurbits: They belong to family Cucurbitaceae which have a characteristic fruit called pepo.

(a) Red pumpkin (Sitaphal): *Cucurbita maxima*
(b) Summer squash (Safed kaddu): *Cucurbita pepa*
(c) Bottle guard (Ghia kaddu): *Lagenaria siceraria*
(d) Vegetable sponge (Ghia tori): *Luffa cylindrica*
(e) Round gourd (Tinda): *Citrullus vulgaris*
(f) Bitter gourd (Karela): *Momordica charantia*

(iv) Jack fruit (Kathal): *Artocarpus heterophyllus;* Fam.—Moraceae

- **Cauliflory,** *i.e.*, presence of fruit and flowers on main trunk, is present in Jack fruit.

(G) Fruits

Morphologically ripened ovary with its contents is known as **fruit.** It is the seed bearing part of the plant.

Daily requirement of fruits per adult per day is 3·0 ounces while in India, the daily availability is **1·5 ounces/adult/day.**

Fruits are divided into three main types:

(i) **Simple fruits:** Fruits developing from single ovary.

(ii) **Aggregate fruits:** Fruits developing from numerous free carpels of same flower.

(iii) **Composite fruits:** Fruits developing from complete inflorescence.

For convenience of study the fruits are divided as, **Tropical fruits and Temperate fruits.**

(a) Tropical fruits

(1) Mango (Aam): *Mangifera indica;* Fam.—Anacardiaceae

It is rich source of vitamin A, C and K (Potash).

(2) **Citrus fruits:** These are members of family Rutaceae having a characteristic fruit called **hesperidium** which is a **modified berry.**

- Citrus fruits are rich source of **vitamin C** (ascorbic acid) which is a **antiscorbutic vitamin.**

Some of the important citrus fruits are:

(a) *Citrus aurantifolia* (Kagzi nimbu)
(b) *Citrus aurantium* (Khatta)
(c) *Citrus reticulata* (Mandarin)
(d) *Citrus maxima* (Shaddock)
(e) *Citrus sinensis* (Mausambi)

(3) Banana (Kela): *Musa paradisiaca* subsp. *sapientum;* Fam.—Musaceae

It is one of the tallest of the herbs. It is one of the oldest fruits, called 'Adams fig' and 'Apple of Paradise'.

- Banana is cheapest energy rich fruit (healthful and nourishing), having high content of carbohydrates, some fats and proteins.
- Plantain (*Musa paradisiaca*) is a close relative of banana and is always eaten cooked or made into flour, which forms digestible food for invalids and children.

(4) Litchi: *Litchi chinensis;* Fam.—Sapindaceae

Edible part is aril.

(5) Sapodilla (Chiku): *Achras zapota;* Fam.—Sapotaceae

The milky juice, known as chicle is used in manufacture of chewing gums.

(6) Guava (Amrud): *Psidium guajava;* Fam.—Myrtaceae

(7) Jujube (Ber): *Ziziphus mauritiana;* Fam.—Rhamnaceae

(8) Papaya (Papita): *Carica papaya;* Fam.—Caricaceae

Papain enzyme is obtained from papaya used for digesting protein.

(9) Pomegranate (Anar): *Punica granatum;* Fam.—Punicaceae

(10) Pineapple (Ananas): *Ananas comosus;* Fam.—Bromeliaceae

(11) Jambolana (Jamun): *Syzygium cumini;* Fam.—Myrtaceae

(12) Custard apple or Sugar apple: *Annona squamosa;* Fam.— Annonaceae

(13) Fig (Anjeer): *Ficus carica;* Fam.—Moraceae

(14) Bel: *Aegle marmelos;* Fam.—Rutaceae

(b) Temperate Fruits

(1) Apple (Seb): *Pyrus malus;* Fam.—Rosaceae
(2) Pear (Nashpati): *Pyrus communis;* Fam.—Rosaceae
(3) Plum (Alucha): *Prunus domestica;* Fam.—Rosaceae
(4) Peach (Aru): *Prunus persica;* Fam.—Rosaceae
(5) Apricot (Khubani): *Prunus armeniaca;* Fam.—Rosaceae
(6) Strawberry: *Fragaria chiloensis;* Fam.—Rosaceae
(7) Raspberry: *Rubus ellipticus;* Fam.—Rosaceae
(8) Grapes: *Vitis vinifera;* Fam.—Vitaceae

Chief varieties are **Anab-e-Shahi, Gulabi, Kali Sahebi,** Kandhari, etc.

WOODS OR TIMBERS

Secondary xylem is called wood.

- Angiospermous wood having vessels is known as **porous wood** while the vesselless gymnospermous wood is known as **non porous wood.**
- Wood formed during spring season and having larger xylem elements is known as **spring wood or early wood** while the wood formed during winter or autumn having smaller xylem elements is known as **winter wood or autumn wood or late wood.**

- Wood peripheral in position in stem, which is **lighter** in colour and meant for **conduction of water and minerals** is known as sap wood or alburnum while the central portion of wood which is dark in colour due to the deposition of **tannins, resins, gums** and **tyloses** is called **dark wood** or **heart wood or duramen.** It performs mechanical function.
- Drying of wood or minimizing water content of wood is known as seasoning of wood. It can be done by two ways, either naturally by air seasoning or artificially by kiln seasoning.

Important woods

(1) Lightest wood : Balsa wood or *Ochroma*.

It is found in tropical America.

- Equador fulfills 90% of world's supply.

1 cubic ft of wood is equal to **ten pounds** and specific gravity = 0·12.

(2) Heaviest wood :

(i) Iron wood : *Krugiodendron ferrum*

(ii) Lignum vitae : *Guaiacum officinale*

- Specific gravity is 1.3 or 1.4.

(3) Walnut wood : *Juglans regia.*

- It is best carving wood.

Riffle butts and gun stocks are made of this wood.

(4) White willow : *Salix alba*

- **Cricket bats** are made of this wood.

(5) Mulberry wood : *Morus alba*

- **Indian Hockey sticks** which are considered best are made up of this wood. Tennis rackets, badminton rackets, stumps, etc., are also made of this wood.

(6) Ebony wood : *Diospyros ebenum.*

- **Billiards cue shaft** is made of *Diospyros* wood.

(7) Indian red wood (Sissoo wood) : *Dalbergia sissoo.* This wood is used in making furnitures, doors because of its great strength and durability.

(8) Indian rose wood or Indian black wood : *Dalbergia latifolia*

(9) Australian black wood : *Acacia melanoxylon*

(10) Red wood : *Sequoia sempervirens*

It is one of the **largest trees** in world having a height up to **360 ft.**

Big tree of California : *Sequoia gigantea.* The age of this tree is estimated about 3600 years having a diameter of 8–22 ft.

(11) Teak wood (Sagaun) : *Tectona grandis*

Most durable wood in India. Its durability is because of a **resinous fluid** present in it, which protects it from action of water.

- In Karli caves near Pune, the teak wood work which is two thousand years old, still is in good condition.

(12) Sal wood : *Shorea robusta*

- After seasoning, sal wood attains maximum strength and durability.

Railway sleepers, door frames, etc., are made from its wood.

(13) Haldoo wood : *Adina cordifolia*

(14) Sideroxylon : Match sticks and boxes are made up of its wood.

(15) Populus : Plywood, match sticks, paper pulp are made of this wood.

Veneers

The veneers are thin slices of wood which are uniform in thickness about $\frac{1}{20}$" to $\frac{3}{8}$". These veneers are glued together to form plywood.

Bhojpatras

These are obtained from the **bark** of *Betula* (Fam—Betulaceae). Bhojpatras were used in earlier times by saints to write.

CORK

Commercial cork is obtained from bark of *Quercus suber* (Fam.—Fagaceae).

- Cork cambium or phellogen cuts off **cork cells** or **phellem** on its outer side and **phelloderm** or **secondary cortex** on inner side. (Phellem, phellogen and phelloderm collectively constitute periderm.)
- Cork cells are impervious to water and hence are buoyant. The water tight nature of cork cells is due to the presence of **suberin** on it cell walls, *i.e.*, **cork cells are suberized.**
- **Portugal** is the largest cork-producing and exporting country in the world.

RUBBER

Rubber is obtained from the **latex** (milky juice) of plants belonging mainly to **Moraceae, Euphorbiaceae** or **Apocynaceae** families. Some of the tropical and sub-tropical plants which are good source of rubber are:

(1) Hevea or Para rubber tree : *Hevea brasiliensis;* Fam.—**Euphorbiaceae**

- It is the most important source of rubber in world and **98%** of world's supply is fulfilled by Hevea rubber.

(2) Indian rubber : *Ficus elastica;* Fam.—**Moraceae**

It is native of **India** and **Malaya.** In India it is found in **Assam** and **Khasia hills.**

(3) Dandelion rubber or Russian dendelion : *Taraxacum kok-saghyz*

Good quality rubber is obtained from the **roots** of the plant.

(4) Mexican guayule : *Parthenium argentatum;* Fam.—**Compositae**

Rubber obtained from this plant is of inferior quality and is extracted from the whole plant.

(5) **Panama rubber :** *Castilla elastica;* Fam.—Moraceae

(6) **Gutta parcha :** *Palaquim gutta;* Fam.—Sapotaceae
It is non elastic rubber.

(7) **Ceara rubber :** *Manihot glaziovii;* Fam.—Euphorbiaceae

FIBRES

Fibres come next to food plants in their importance to man kind.

- Fibres are generally sclerenchymatous cells with deposition of lignin and cellulose. These are elongated, thick-walled cells with tapering ends.

The fibres are divided into three categories–

(i) **Surface fibres :** Cotton
(ii) **Soft fibres :** Flax, jute, hemp and ramie
(iii) **Hard fibres :** Coconut, pineapple, sisal.

(i) Surface fibres

Cotton—*Gossypium species;* Fam.—Malvaceae

Cotton is obtained from four species of the genus *Gossypium, i.e.,*

Gossypium arboreum—Old world species
Gossypium herbaceum—Old world species } $2n = 26$ (diploid)

Gossypium hirsutum—New world species
Gossypium barbadense—New world species. } $2n = 52$ (tetraploid)

Thus cotton is both a new world and-old world crop. It is the oldest and world's greatest industrial crop.

- It grows best in black soil, mostly grown in **Gujarat and Maharashtra.**

Cotton is a **surface fibre,** *i.e.,* fibres arise from seed coat. These fibres are single celled made mainly of cellulose (some amount of lignin is also present). The long fibres are upto 45 mm in length which are called **lint fibres** whereas the small fibres are called **fuzz fibres.**

- Important varieties of cotton are: **Virnar, Jarila, Daulet, Jayawant, Vijay, Digvijay,** etc.

Cotton is very useful raw material for various industries, *i.e.,* **plastic, rayon and explosives.**

Fibres are present in the stalk of the plant which are used for paper making.

Cotton seed oil is obtained from kernels which is one of the most important **fatty oils.**

(ii) Soft fibres

(a) Flax (Alsi) : *Linum usitatissimum;* Fam.—**Linaceae**

Fibres of flax are obtained from pericycle. These fibres are stronger and durable than cotton fibres.

○ Flax fibres are **moisture or water resistant** so used in making **fishing nets, ropes.** These fibres become more strong when wet than dry.

(b) Jute (Patsan) : *Corchorus capsularis* and *Corchorus olitorius;* Fam.—Tiliaceae.

- India is the largest exporter of jute and jute products.
- Jute is a **bast fibre** obtained from the secondary phloem.

These fibres are used in making carpets, curtains, twines, ropes, etc.

- Jute fibres deteriorate rapidly when exposed to moisture.

(c) **Sun hemp (San) :** *Crotolaria juncea;* Fam. — **Papilionaceae**

The fibres of sunhemp are obtained from phloem and pericycle. These are used in making coarse cloth, ropes and twine, etc.

(d) **Bimli Jute (Patsan) :** *Hibiscus cannabinus;* Fam.—Malvaceae

These fibres are **cortical fibres** and are used for making ropes, sacks and gunny bags, etc.

(e) **Hemp (Bhang) :** *Cannabis sativa;* Fam.—Cannabinaceae

The hemp fibres are obtained from **pericycle.** These are used in making ropes, carpets, sail cloth, etc.

(f) **Remie (China grass) :** *Boehmeria nivea;* Fam.—Urticaceae

○ Longest, toughest, strongest and most durable fibres are obtained from **secondary phloem,** used for ropes, brushes, carpets, etc.

(iii) Hard fibres

(a) **Manila hemp or Abaca :** *Musa textilis;* Fam.—Musaceae

The fibres are obtained from the leaf.

(b) **Bow string hemp :** *Sansevieria;* Fam.—**Liliaceae**

The fibres are obtained from leaves.

(c) **Coir (Nariyal) :** *Cocos nucifera;* Fam.—**Palmae**

The mesocarp is fibrous and the fibres of this plant are highly resistant to water.

(d) **Sisal hemp :** *Agave sisalana;* Fam.—**Agavaceae**

Yellowish, stiff fibres are obtained from leaves and are used for making ropes and twines.

TANNINS

Tannins are organic compounds, glucosidal in nature and having acidic reaction. These are **complex glucosides** of gallic acid and are also known as tannic acid.

Tannins are obtained from insect galls.

These are the basis of **blue black inks,** *i.e.,* gallic acid + ferrous sulphate + little colouring matter ⟶ blue black ink

DYES

Dyes are **coloured compounds** capable of being fixed to fabrics which do not come out on washing with soap.

These can be obtained from **woods, leaves, flowers** or **rhizomes.**

(I) Dyes obtained from woods

(1) Log wood (Patang) : **Haematoxylin** stain or dye is obtained from heart wood of ***Haematoxylon campechianum;*** Fam.—**Caesalpiniaceae**

(2) Cutch or Khair or Kattha or Catechu : It is obtained from the wood of *Acacia catechu*; Fam.—**Mimosaceae**

Kattha is prepared mainly in **Bareilly (U.P.)** and **Gwalior (M.P.)**

(3) Sappan wood (Gulal): This dye is obtained from the heart wood of *Caesalpinia sappan*; Fam.—**Caesalpiniaceae**

(II) Dyes obtained from leaves

(1) Indigo (Neel) : From the leaves of *Indigofera tinctoria*, Fam.—**Papilionaceae**, this dye is obtained which is used for whitening the clothes.

(2) Henna (Mehndi) : This is orange dye, obtained from the leaves of *Lawsonia inermis*, Fam.— **Lythraceae**

(III) Dyes obtained from flowers

(1) Safflower (Kusum) : This is yellow dye obtained from the flowers of *Carthamus tinctorius;* Fam.—**Compositae**

(2) Flame of the forest or Tesu or Palash or Dhak or Bengal kino : This dye is obtained from the flowers of *Butea monosperma*; Fam.—**Papilionaceae**

It is yellow in colour.

(3) Saffron or Kesar or Zaffran : This is yellow orange coloured dye obtained from flowers of *Crocus sativus;* Fam.—**Iridaceae**

- ○ Kesar is obtained from **dried stigmas and upper part of styles.**
- ● It is mainly grown in village **Palmpur of Jammu & Kashmir**
- ○ One ounce of kesar is obtained from 4000 flowers.

(4) Tree of sorrow (Harsingar) : *Nyctanthes arbor-tristis;* Fam.—**Oleaceae**

An orange coloured dye is obtained from its flowers, which is used for colouring cotton and silk.

(IV) Dye obtained from the rhizomes

Turmeric (Haldi).

From the rhizomes of turmeric–*Curcuma domestica* (Fam.—Zingiberaceae), a yellow coloured dye is obtained which is used to colour food stuffs.

SUGARS

(1) Sugar cane : *Saccharum officinarum;* Fam.—**Gramineae**

Sugar cane industry is next to cotton industry in India.

- ● Chief source of sugar in world is sugar cane.

Sugar cane contains about 10% of juice. The sugar content of which is about 12–13%. Although sugar cane is grown in different state of India but U.P. is the largest producer of sugar cane.

Important varieties of sugar cane are– **CO-312, CO-313, CO-419, CO-453, CO-548, CO-1148, BO-17,** etc.

- ● The chief by-products of sugar industry are **bagasse** and **molasses.** Bagasse is used for paper making and molasses in manufacturing rum and industrial alcohol.

(2) Sugar beet : *Beta vulgaris;* Fam.—**Chenopodiaceae**

Beet roots are the second important source of sugar in world.

(3) Palm : Several species of palms are a source of commercial sugar. Some of the important ones are:

(a) Date palm : *Pheonix sylvestris;* Fam.—**Palmae**

The upper portion of stem is tapped to obtain juice or sap which contains about 14% of sugar content. The crude sugar obtained from date palm is known as **jaggary.**

(b) Palmyra palm : *Borassus flabellifer*

(c) Toddy palm : *Caryota urens.*

STARCH

Starch is a complex carbohydrate obtained from **wheat, barley, maize, potatoes** and **arrowroot.**

- ○ Sago starch is obtained from the stems of **sago palm**—*Metroxylon sago.*

FUMITORIES AND MASTICATORIES

Fumitories are those substances which are used for **smoking** while **Masticatories** are used for **chewing.**

(1) Tobacco : *Nicotiana tabacum*; Fam.—**Solanaceae**

It is mainly used for **chewing** and for **snuffing.**

- ○ In tobacco **alkaloid nicotine** is present which is responsible for narcotic and soothing properties.

(2) Arecanut (Supari) : *Areca catechu;* Fam.—**Palmae**

(3) Betel (Pan) : *Piper betle;* Fam.—**Piperaceae**

It is a popular masticatory and is digestive, stimulant and carminative. It is said to be a good source of calcium.

(4) Catechu (Kattha) : *Acacia catechu;* Fam.—**Mimosaceae**

It is obtained from the heart wood and mainly applied on betel leaf.

(5) Coca : *Erythroxylon coca*; Fam.—**Erythroxylaceae**

The drug **cocaine** (cokeen) is obtained from the powdered leaves of this plant. Its powder (snow) is used as snuff and also resists physical and mental fatigue.

(6) Hemp : *Cannabis sativa;* Fam.—**Cannabinaceae**

From the female flowering tops and leaves a resin, **charas** or **hashish** is obtained which is used as a **narcotic stimulant.**

Bhang is obtained from the young dried leaves and flowering shoots of both male and female plants. In America it is known as **marijuana.**

Ganja is the dried unfertilized female flowering tops covered with resinous substance. *Cannabis* is having **stupefying** and **hypnotic** effect. It is also called **delight giver** and **dream inducer.**

(7) Opium : *Papaver somniferum*; Fam.—**Papaveraceae**

Opium is the latex obtained from the unripe capsules of *Papaver.*

A number of alkaloids have been isolated from opium, till now 25 are known. Out of these alkaloids morphine and codeine are the important ones. Morphine is analgesic and have sleep and dream inducing properties, while codeine being milder than morphine, is used in cough syrup.

- There are two important derivatives of morphine, one is brown sugar or smack (Diacetyl morphine hydro-chloride) and another is heroin [morphine + $(CH_3CO)_2O$].

NON-ALCOHOLIC BEVERAGES

The important and popular non-alcoholic beverages are **tea, coffee and cocoa.**

In these beverages an alkaloid caffeine is present, which is diuretic and stimulant.

(1) **Tea :** *Camellia sinensis;* Fam.—Theaceae

Tea is considered as 'Queen' of non-alcoholic beverages.

- India ranks second in the production of tea after China and is number one in exporting tea.
- In India tea is mainly grown in Assam, Darjeeling, Tripura, Kangra and Nilgiris.

From each shoot two young leaves and a bud are plucked, which are source of tea.

(2) **Coffee :** *Coffea arabica;* Fam.—**Rubiaceae**

Coffee plant is a native of Abyssinia. In India it is grown in **Karnataka, Madras** and **Kerala.** Indian coffee is considered to be of high quality because of its good flavour. Coffee is obtained from seeds.

(3) **Cocoa and chocolate :** *Theobroma cacao;* Fam.—**Sterculiaceae**

It is a native of tropical America.

For the preparation of cocoa and chocolates, the seeds are used.

(4) **Fruit and vegetable juices :** The simplest and nutritive soft drinks are the juices of various fruits and vegetables, which are flavoured by Khus–*Vetiveria zizanioides.*

SPICES AND CONDIMENTS

Spices and condiments are generally hard parts of plants used in pulverized state for flavour. These can be obtained from different parts of plants–

(1) Spices obtained from roots and underground parts

(i) **Asafoetida** (Hing): *Ferula asafoetida;* Fam.—**Umbelliferae**

It is a gum resin obtained from the **roots** of the plant. Asafoetida is generally used for flavouring objects and in medicines for cough and indigestion.

(ii) **Turmeric** (Haldi) : *Curcuma domestica;* Fam.—**Zingiberaceae**

It is obtained from rhizomes and used as a condiment to colour food stuffs.

(iii) Ginger (Adrak) : *Zingiber officinale;* Fam.—Zingiberaceae

It is obtained from rhizomes.

(2) Spices obtained from flowers

(i) Clove (Laung) : *Syzygium aromaticum;* Fam.—Myrtaceae

These are the dried unopened flower buds used for flavouring pickles, curries, etc. It is carminative and stimulant.

(ii) **Saffron** (Kesar) : *Crocus sativus* ; Fam.—**Iridaceae**

Saffron is obtained from the **dried stigmas and tops** of the style. It has a pleasant aroma.

(3) Spices obtained from fruits

(i) **Black pepper (Kali mirch) :** *Piper nigrum;* Fam.—Piperaceae .

- It is known as **'King of spices'** or **'Black Gold of India'.**

(ii) **Vanilla :** *Vanilla planifolia;* Fam.–**Orchidaceae**

The vanilla odour is obtained from the fruits of an orchid, *Vanilla planifolia.* This fragrance is due to a crystalline substance **'vanillin'.**

(iii) **Indian long pepper** (Pipal) : *Piper longum;* Fam.—Piperaceae

(iv) **Coriander** (Dhaniya) : *Coriandrum sativum;* Fam.—**Umbelliferae**

(v) **Fennel** (Saunf) : *Foeniculum vulgare;* Fam.—**Umbelliferae**

(4) Spices obtained from seeds

(i) **Cardamom** (Chhoti elaichi) : *Elettaria cardamomum;* Fam.—Zingiberaceae

- It is known as **'Queen of spices'.**
- **Cardamom hills are present in Kerala.**

(ii) **Bengal Cardamom** (Bari elaichi) : *Amomum aromaticum;* Fam.—**Zingiberaceae**

(iii) **Fenugreek** (Methi) : *Trigonella foenum–graecum;* Fam.—**Papilionaceae**

(5) Spices obtained from bark

Cinnamon (Dalchini) : *Cinnamomum zeylanicum;* Fam.—Lauraceae

(6) Spices obtained from leaves

(i) **Peppermint** (Vilayati pudina) : *Mentha piperita;* Fam.—Labiatae

(ii) Mint (Pudina) : *Mentha longifolia;* Fam.—**Labiatae**

(iii) **Indian Cassias** (Tejpat) : *Cinnamomum tamala;* Fam.—**Lauraceae.**

ESSENTIAL OILS OR VOLATILE OILS

Essential oils evaporate in contact with air and have a pleasant fragrance. The important essential oils are:

(1) **Khus oil :** *Vetiveria zizanioides;* Fam.—**Gramineae**

It is obtained from **roots** and **rhizomes** and is used for preparing and flavouring fruit juices, ice-creams, etc.

(2) Terpentine oil : *Pinus longifolia;* Fam.—**Pinaceae**

It is obtained by distillation of oleoresin which is an exudate coming out after wounding the tree.

(3) Geranium oil : *Pelargonium graveolens;* Fam.—**Geraniaceae**

This oil is obtained from leaves and twig of the plant.

(4) Jasmine oil : *Jasminum auriculatum;* Fam.—**Oleaceae**

This oil is obtained from flowers of the plant used in hair oils and perfumes.

(5) Ylang Ylang oil : *Cananga odorata;* Fam.—**Annonaceae**

The oil obtained after first distillation of flowers is the best and is used in manufacturing perfume in France.

(6) Sandal wood oil : *Santalum album;* Fam.—**Santalaceae**

The oil is used in perfumes, soaps and in medicines.

(7) Lavender oil : *Lavendula officinalis;* Fam.—**Labiatae**

The fresh flowering tops of the plants are used for obtaining oil. It is constituent of **Eau de Cologne** and other high grade perfumes.

(8) Mandarin oil : *Citrus reticulata;* Fam.—**Rutaceae**

This oil is obtained from the peels of fruit and used in confectionery, soaps, etc.

(9) Rose oil or Otto of roses : *Rosa damascena;* Fam.—**Rosaceae**

The rose oil is used in perfumes, soaps, etc.

(10) Lemon-grass oil : *Cymbopogon citratus;* Fam.—**Gramineae**

The leaves on distillation give a reddish-yellow oil with high citral content (70-80%), which is used in perfumes, cosmetics, toilet soaps, bath salts, etc.

(11) Ginger-grass oil and Palmarosa oil : *Cymbopogon martinii*

These are used for adulteration of otto of roses.

(12) Citronella oil : *Cymbopogon nardus*

This oil is obtained by distillation of leaves of this grass, which is used in cheap soaps, perfumes and also as an insect repellant.

(13) Cedar wood oil : *Juniperus virginiana*

This oil is obtained by distillation of heart wood of this eastern red cedar. It is used as clearing agent in preparation of permanent microscopic mounts, in perfumes, soaps, deodorants and also used in fly sprays and as moth repellant.

FATTY OILS OR FIXED OILS

Fatty oils do not evaporate in contact with air so these are also called **fixed oils.**

Chemically, these are esters of long chain fatty acid and glycerol. These are liquid at ordinary temperatures and have unsaturated fatty acids (oleic acid, linolic acid, etc.) usually.

Fatty oils are classified into three categories–

(I) Drying or semi–drying oils
(II) Non–drying oils
(III) Vegetable fats.

(I) Drying or Semi-drying oils

(1) Linseed oil : *Linum usitatissimum;* Fam.—**Linaceae**

In manufacturing paints and varnishes, this oil is used.

(2) Sesame or Gingelly oil : *Sesamum indicum;* Fam.—**Pedaliaceae**

The oil is obtained from the seeds which contain about 50% oil which is used for cooking and manufacturing soap.

(3) Sunflower oil : *Helianthus annuus;* Fam.—**Compositae**

The seeds contain 40–50% oil which is used for cooking, in preparation of vanaspati ghee. It is best for heart patients.

(4) Soybean oil : *Glycine max;* Fam.—**Papilionaceae**

It is a good cooking oil and also used in manufacturing soap, paints, insecticides, etc.

(5) Cotton seed oil : *Gossypium sps;* Fam.—**Malvaceae**

This oil is used for making vanaspati ghee. The seed oil cake is used as cattle feed.

(6) Colza or Sarson oil : *Brassica campestris;* Fam.—**Cruciferae**

The refined sarson oil is used as cooking oil and in pickles.

- Mustard seeds are adulterated with seeds of *Argemone mexicana* (Pili Katili).

(7) Indian rape oil : *Brassica campestris* var. *toria;* Fam.—**Cruciferae**

The oil is edible and oil cake is used to feed cattle.

(8) Margosa oil : *Azadirachta indica;* Fam.—**Meliaceae**

The oil extracted from the seeds is used as an antiseptic.

(9) Safflower oil : *Carthamus tinctorius;* Fam.—**Compositae**

(10) Hemp oil : *Cannabis sativa;* Fam.— **Cannabinaceae**

(II) Non-drying oils

(1) Peanut oil : *Arachis hypogea;* Fam.—**Papilionaceae**

The refined peanut oil is used for cooking while inferior grade is used in soap making. Peanut oil is also used in making **margarine.**

(2) Olive oil : *Olea europaea;* Fam.—**Oleaceae**

Olive oil is obtained from the **fruit pulp.**

It is used as salad or cooking oil, lubricant and in soap making.

(3) Castor oil : *Ricinus communis;* Fam.—**Euphorbiaceae**

Castor oil is used as **purgative.** It is an excellent lubricant.

(III) Vegetable fats

(1) Coconut oil : *Cocos nucifera;* Fam.—**Palmaceae**

The refined oil is used for cooking and in preparing various food stuffs. It is also used in soaps, cosmetics, shampoos, etc.

(2) Palm oil : *Elaeis guineensis;* Fam.—**Palmaceae**

It is used in making soap. The refined oil is used in margarine.

(3) Mahua oil : *Madhuca indica;* Fam.—**Sapotaceae**

In manufacturing laundry soap, this oil is used. In some rural areas mahua oil is used for cooking also.

MEDICINAL PLANTS

The history, identification, collection and preservation of drugs is known as '**Pharmacognosy**' and the study of action of drugs is known as Pharmacology.

- **Hippocrates** is called the 'father of medicine'.

Some plants have medicinal value due to the presence of some **chemical substances** in their parts which have a definite **physiological effect** on body.

Depending upon the plant organ from which the drug is obtained, the drug plants are divided into following categories:

(I) Drugs obtained from roots

(i) **Aconite** (Atis): *Aconitum heterophyllum;* Fam.—Ranunculaceae

(ii) **Belladona** (Sag–angur): *Atropa belladona;* Fam.—**Solanaceae**

- ○ Atropine alkaloid is obtained from it which is used for dilating pupil of eye (*i.e.,* in eye testing).

(iii) **Liquorice** (Mulehthi): *Glycyrrhiza glabra;* Fam.—**Papilionaceae**

The roots contain glycyrrhizic acid. It is expectorant, laxative given in bronchitis and chest complaints.

(iv) **Serpentine** (Sarpagandha): *Rauwolfia serpentina;* Fam.—**Apocynaceae**

About **30 alkaloids** are extracted from root of this plant. Out of which '**reserpine**' is the most important one having sedative influence and is used in lowering the blood pressure.

(v) **Ashwagandha :** *Withania somnifera;* Fam.—**Solanaceae**

It is effective in treatment of rheumatic pain, inflammation of joints, ulcers and to promote healing processes.

(vi) **Asafoetida** (Hing): *Ferula asafoetida;* Fam.—**Umbelliferae**

This is oleo-resin gum exuding from the roots. It is carminative, digestive and antispasmodic.

(II) Drugs obtained from stem and other underground parts

(i) **Turmeric** (Haldi): *Curcuma domestica;* Fam.—**Zingiberaceae**

(ii) **Ginger** (Adrak): *Zingiber officinale;* Fam.—**Zingiberaceae**

(iii) **Onion** (Pyaz): *Allium cepa;* Fam.—**Liliaceae**

(iv) **Garlic** (Lahsun): *Allium sativum;* Fam.—Liliaceae

(v) **Red squill** (Sea-onion): *Urginea maritima*; Fam.—**Liliaceae**

The bulbs of red variety of sea–onion is the source of red squill which is used as a **raticide** from ancient times, although it has little effect on other animals.

(III) Drugs obtained from the leaves

(i) **Holy basil** (Tulsi): *Ocimum sanctum;* Fam.—**Labiatae**

- The leaf juice is given in cold, cough and chronic fever and is used to check vomiting.

(ii) **Betel pepper** (Pan): *Piper betle;* Fam.—**Piperaceae**

(iii) **Vasaka :** *Adhatoda vasica;* Fam.—**Acanthaceae**

The alkaloid vascine is present in the leaves which is expectorant and antispasmodic.

(IV) Drugs obtained from the flowers

(i) **Saffron** (Kesar): *Crocus sativus;* Fam.—**Iridaceae**

The dried stigmas and tops of the style are medicinally used.

(ii) **Santonin :** *Artemisia cina;* Fam.—**Compositae**

A valuable drug santonin is present in the dried unopened flower heads of the plant. This drug is one of the best remedies of intestinal worms (wormicide).

(iii) **Violet** (Banafsha): *Viola odorata;* Fam.—Violaceae

The flowers are used for the treatment of coughs.

(iv) **Iron wood** (Nag champa): *Mesua ferrea;* Fam.—Guttiferae

- ○ A tree and its flowers are source of '**Nagkesar**'. The flowers are used as astringent and stomachic.

(V) Drugs obtained from bark

(i) **Cinnamon** (Dalchini): *Cinnamomum zeylanicum;* Fam.— Lauraceae

(ii) **Quinine** (Kunain): *Cinchona calisaya;* Fam.—Rubiaceae

The only adequate cure of malaria '**Quinine**' is obtained from the thick bark of *Cinchona* sps.

- ○ First of all this drug was used in **Peru in 1638** (When Countess of Chinchon, wife of Viceroy of Peru was cured of malaria).

(VI) Drugs obtained from fruits

(i) **Emblica** (Amla): *Emblica officinalis;* Fam.—**Euphorbiaceae**

It is one of the richest sources of **vitamin C.** Amla is a good astringent and blood purifier.

(ii) **Bael :** *Aegle marmelos;* Fam.—**Rutaceae**

The fruit is cooling, laxative, stomachic and digestive.

(iii) **Opium** (Afim): *Papaver somniferum,* Fam.—Papaveraceae

A brownish material (latex) is present in crude opium having 25 alkaloids, out of which **morphine** and **codeine** have great medicinal value.

(iv) **Black pepper :** *Piper nigrum;* Fam.—**Piperaceae**

These contain an alkaloid **piperine.**

The fruits are used in various diseases, *e.g.,* cough, malarial fever, disorders of urinary system, etc.

(v) **Chebulic myrobalan** (Harad): *Terminalia chebula;* Fam.—**Combretaceae**

The fruits of this tree are source of **Harad** or **Haritaki**, which is important ingredient of ayurvedic medicine 'Trifla':

(VII) Drugs obtained from seeds

(i) Croton (Jamalgota): *Croton tiglium;* Fam.—**Euphorbiaceae**

Croton oil is obtained from the seeds which is a strong purgative.

(ii) Blonde psyllium (Isafgol): *Plantago ovata;* Fam.—**Plantaginaceae**

In the seed coat or husk of *Plantago* mucilagenous matter is found. Therefore, its husk is used in treatment of dysentry, constipation and various diseases of digestive system.

(iii) Nux–Vomica (Kuchla): *Strychnos nux-vomica,* Fam.—**Loganiaceae**

The drug **nux–vomica** is obtained from the ripe seeds which is used in the treatment of nervous disorders, chronic rheumatism, hydrophobia, etc.

- **Strychnine alkaloid** is present in the seeds.

(VIII) Drugs obtained from woods

(i) White sandal wood: *Santalum album;* Fam.—**Santalaceae**

The wood is cooling, astringent and diuretic.

(ii) Catechu (Katha): *Acacia catechu;* Fam.—**Mimosaceae**

Being a valuable astringent it is used in chronic **diarrhoea, dysentry, bleeding piles,** etc.

(iii) Long needled pine (Chir): *Pinus roxburghii;* Fam.—**Pinaceae**

The oleo–resin is present in the wood which is popularly known as **gandh–biroza** and is stimulant and diuretic.

(iv) Dried stem of *Ephedra gerardiana* yields **'Ephedrine'**, used in cough, asthama and cold.

PAPER

The word 'paper' has been derived from Latin word–*Papyrus,* which is the name of a plant belonging to family **Cypraceae.** The pith of this plant was first used in paper making.

The paper was first of all produced in **China.** Nowadays there are various natural sources which provide raw material for paper making.

- Spruce (*Picea* sps.) is the most important source which fulfils 30 per cent of total supply in world and has maximum per cent of cellulose.
- In India 80% of raw material is obtained from **bamboo** (*Bambusa* sps.) and rest is obtained from **sabai grass,** bagasse and **Eucalyptus wood.**
- Largest news paper industry is in **Nepanagar.**

OLD WORLD AND NEW WORLD CROPS

Depending upon the centre of origin, **A.P. de Candolle** divided crops into two main types, *i.e.,* old world crops and new world crops.

According to **Vavilov,** about 85% of crops are old world crops and 15% are new world crops.

(i) Old world crops

These are crops which have their centre of origin as Asia, Africa and Europe, *e.g.,* apple, almond, banana, barley, oat, millets, tea, rice, mango, grapes, wheat, onion, cotton (*Gossypium arboreum* and *Gossypium herbaceum*), mustard, pea, sugar cane, radish, citrus, kuttu, coffee and okra.

(ii) New world crops

These are crops which have their centre of origin as America, *e.g.,* maize, potato, sweet potato, tobacco, tomato, groundnut, kidney bean, guava, pumpkin, pepper, rubber, cotton (*Gossypium hirsutum* and *Gossypium barbadense*).

Hevea brassilensis
Solanum tuberosum
Nicotiana tobacum
Lycopersicum esculentum

MULTIPLE CHOICE QUESTIONS

1. Largest area of cultivation in India is of:
   (a) Wheat (b) Rice
   (c) Maize (d) Sorghum
2. The most important foods are derived from:
   (a) Legumes (b) Karyopsis
   (c) Berry (d) Pepo
3. Important beverage 'Sake' of Japan is obtained from:
   (a) Wheat (b) Rice
   (c) *Vitis* (d) Barley
4. 'Jagannath' is an important cultivar of:
   (a) Wheat (b) Sugar cane
   (c) Rice (d) Maize
5. Maximum carbohydrate content is in:
   (a) Rice (b) Wheat
   (c) Maize (d) Sorghum
6. Which is the largest of cereals?
   (a) Sorghum (b) Maize
   (c) Barley (d) Rye
7. Which one is a variety of maize?
   (a) IR-8 (b) Ganga-5
   (c) KSML-3 (d) CO-1148
8. Artificial woolly fibres are obtained from:
   (a) Rice (b) Maize
   (c) Wheat (d) *Secale*

*9. Black bread is obtained from :
   (a) Wheat (b) Barley
   (c) *Secale* (d) Sorghum

10. First man made cereal is: **(BHU 1999, 2000)**
    (a) Oat (b) Barley
    (c) *Triticale* (d) Ragi
11. Foxtail millet is :
    (a) *Eleucine* (b) *Setaria*
    (c) *Pennisetum* (d) None of these
12. One of the hardiest crop for dry farming which is pest and disease resistant is:
    (a) Pearl millet (b) Proasso millet
    (c) Finger millet (d) Foxtail millet
13. Wheat is a:
    (a) Rabi crop (b) Kharif crop
    (c) Both (a) and (b) (d) None of these
14. Buck wheat (Kuttu) is obtained from a member of a family:
    (a) Gramineae (b) Leguminosae
    (c) Polygonaceae (d) Nymphaeaceae
15. 'Urease' enzyme is obtained from:
    (a) Chick pea (b) Pigeon pea
    (c) Garden pea (d) Cow pea
16. Source of 'Ardil'–a synthetic fibre is:
    (a) Peanut (b) Soybean
    (c) *Cajanus* (d) Jack bean
17. Algaroba is:
    (a) *Ceratonia* (b) *Prosopis*
    (c) *Arachis* (d) None of these
18. Highest protein %age is in seeds of : **(MPPMT 2002)**
    (a) *Cajanus cajan* (b) *Glycine max*
    (c) *Vicia faba* (d) *Cicer arietinum*
19. Which is called 'Kalpvariksha'?
    (a) Cashewnut (b) Coconut
    (c) Chestnut (d) Almond
20. Maximum production of coconut is in which state?
    (a) Karnataka (b) Kerala
    (c) Tamilnadu (d) A.P.
21. Which is a true nut?
    (a) Coconut
    (b) Chestnut (*Castanea*)
    (c) Cashewnut (*Anacardium*)
    (d) Walnut (*Juglans*)
22. Daily requirement of vegetables/adult is:
    (a) 5 ounces (b) 10 ounces
    (c) 2.0 ounces (d) 8 ounces
23. Tapioca (root vegetable) is obtained from:
    (a) *Ipomoea* (b) *Dioscorea*
    (c) *Manihot* (d) None of these
24. Which weed is recommended for bio-gas production in India?
    (a) *Hydrilla* (b) *Eichhornia crassipes*
    (c) *Solanum xanthocarpum* (d) *Euphorbia hirta*
25. Which state is largest producer of sugar cane in India? **(CBSE 1991; MPPMT 2002)**
    (a) A.P. (b) U.P.
    (c) Rajasthan (d) Punjab
26. Which is most common stem vegetable in world?
    (a) Taro (b) Potato
    (c) Sweet potato (d) Tapioca
27. 'Kufri Sheetman' is variety of:
    (a) Maize (b) Potato
    (c) Tomato (d) Carrot
28. 'Chilgoza' is obtained from:
    (a) *Cycas revoluta* (b) *Ephedra*
    (c) *Pinus gerardiana* (d) *Ginkgo biloba*
29. Potato and tomato are:
    (a) Old world sps.
    (b) New world sps.
    (c) Old world and new world respectively
    (d) New world and old world respectively
30. In cauliflower (herbage vegetable), which portion is edible?
    (a) Leaves (b) Inflorescence
    (c) Stem (d) Fruits
31. Chewing gum (latex like material) is obtained from:
    (a) *Shorea robusta* (b) *Annona squamosa*
    (c) *Achras zapota* (d) *Boswellia*

32. Which is a good source of Vitamin A?
(a) Gram (b) Banana
(c) Mango (d) Wheat

33. 'Shaddock' is obtained from:
(a) *Citrus reticulata* (b) *Citrus maxima*
(c) *Achras zapota* (d) None of these

*34. Porous wood is generally of:
(a) Angiosperms (b) Gymnosperms
(c) Both (a) and (b) (d) None of these

35. Which is a source of good timber?
(a) Sap wood (b) Heart wood
(c) Both (a) and (b) (d) None of these

(JIPMER 2002)

36. Lightest wood is of:
(a) *Krugiodendron* (b) *Ochroma*
(c) *Dalbergia* (d) *Leitneria*

37. Heaviest wood is of:
(a) Balsa wood (b) *Krugiodendron*
(c) *Salix* (d) *Shorea robusta*

38. Rifle butts (Gun stocks) are made of:
(a) Walnut wood (b) *Morus alba*
(c) *Salix* (d) Teak

39. Best cricket bats are made of which wood?
(a) *Morus alba* (b) *Salix alba*
(c) *Fraxinus* (d) *Populus*

40. Indian black wood is obtained from:
(a) *Dalbergia sissoo* (b) *Dalbergia latifolia*
(c) *Acacia melanoxylon* (d) *Guaiacum officinale*

41. 'Haldoo wood' is obtained from:
(a) *Tectona grandis* (b) *Shorea robusta*
(c) *Sweitenia* (d) *Adina cordifolia*

42. Most durable wood in India is of:
(a) *Shorea robusta* (b) *Tectona grandis*
(c) *Sequoia* (d) *Dalbergia sissoo*

43. The famous wood work at Karli caves (near Pune) is of:
(a) Sal wood (b) Teak
(c) Walnut (d) Sissoo

44. Commercial cork is obtained from:
(a) Bark of *Sequoia* (b) Bark of *Quercus*
(c) Latex of *Hevea* (d) None of these

45. Water tight cork cells (buoyant) are due to deposition of:
(a) Lignin (b) Suberin
(c) Cutin (d) Silica

46. Para rubber is obtained from:
(a) *Hevea* (b) *Ficus*
(c) *Manihot* (d) *Castilla*

47. Source of Assam rubber (Indian rubber) is:
(a) *Castilla* (b) *Manihot glaziovi*
(c) *Ficus elastica* (d) *Hevea brasiliensis*

48. A commercial fibre of seed epidermal origin is:
(a) Flax (b) Cotton
(c) *Bombax* (d) Coir

49. Cotton is a:
(a) Old world sps.
(b) New world sps.
(c) Both old and new world sps.
(d) None of these

*50. *Triticale* is a:
(a) Old world sps. (b) New world sps.
(c) Both (a) and (b) (d) None of these

51. Moisture resistant bast fibre is:
(a) Flax (b) Jute
(c) Hemp (d) Coir

52. Which is the basis of blue black ink?
(a) Khair (b) Indigo
(c) Tannin (d) None of these

53. Hemp fibres are obtained from:
(a) Pericycle (b) Phloem
(c) Cortex (d) Mesocarp

54. A commercial fibre of monocot origin is:
(a) Flax (b) Coir
(c) Jute (d) Hemp

55. Cutch (khair) is obtained from a member of family:
(a) Malvaceae (b) Labiatae
(c) Mimosaceae (d) Asteraceae

56. 'Neel' is obtained from:
(a) *Curcuma* (b) *Lawsonia*
(c) *Indigofera* (d) None of these

57. 'Henna' is obtained from leaves of:
(a) *Lawsonia* (b) *Caesalpinia*
(c) *Nyctanthus* (d) *Curcuma*

58. Saffron is obtained from:
(a) Flowers of *Crocus*
(b) Styles and stigmas of *Crocus*
(c) Flowers of *Carthamus*
(d) Seeds of *Carthamus*

59. 'Zaffran' is obtained from a member of family:
(a) Compositae (b) Iridaceae
(c) Lythraceae (d) Papilionaceae

60. 'Kesar' is cultivated mainly in:
(a) Ghazipur (U.P.) (b) Palampur (J&K)
(c) Bhersar (U.P.) (d) None of these

61. Richest source of Vitamin C is:
(a) *Citrus* (b) Pepper
(c) Tomato (d) *Emblica*

62. Who is known as 'father of medicine'?
(a) Theophrastus (b) Charak
(c) Hippocrates (d) Aristotle

63. 'Belladona' is obtained from a member of family:
(a) Cruciferae (b) Solanaceae
(c) Malvaceae (d) Asteraceae

64. A hypertension drug is obtained from: **(Raj. PMT 2001)**
(a) Roots of *Ferula* (b) Roots of *Rauwolfia*
(c) Stem of *Rauwolfia* (d) Roots of *Digitalis*

65. 'Hing' of commerce (asafoetida) is obtained from latex of:
(a) Roots of *Ferula* (b) Fruits of *Ferula*
(c) Stem of *Ferula* (d) Leaves of *Ferula*

66. Malaria drug (quinine) is obtained from: **(MPPMT 1999)**
(a) Leaves of *Cinchona* (b) Bark of *Cinchona*
(c) Fruits of *Cinchona* (d) Roots of *Cinchona*

67. 'Vasaka' is obtained from:
(a) *Santalum* (b) *Adhatoda*
(c) Emblic (d) Opium plant

68. Source of 'Liquorice' is:
(a) Roots of *Aconitum* (b) Roots of *Glycyrrhiza*
(c) Stem of *Glycyrrhiza* (d) Roots of *Atropa*

69. A hallucinogenic drug is obtained from latex of unripe capsules of:
(a) *Rauwolfia* (b) *Papaver*
(c) *Coffea arabica* (d) None of these

70. 'Nux-vomica' is obtained from:
(a) *Datura* (b) *Strychnos*
(c) *Atropa* (d) None of these

71. India is largest exporter in world of:
(a) Rice (b) Tea
(c) Coffee (d) None of these

72. Which is known as 'Queen of non-alcoholic beverages'?
(a) Khus (b) *Thea*
(c) Coffee (d) Cola

73. Chocholate is prepared from:
(a) Seeds of coffee (b) Seeds of *Theobroma*
(c) Seeds of *Erythroxylon* (d) None of these

74. Source of non-alcoholic drink is:
(a) *Triticum aestivum* (b) *Vetiveria zizanioides*
(c) *Cymbopogon citratus* (d) *Dendrocalamus*

75. Chief source of sugar in world is: (MPPMT 1999)
(a) Sugar cane (b) Beet roots
(c) Datepalm (d) *Borassus* (Palymra palm)

76. Co-1148 is an important variety of:
(a) Wheat (b) Cotton
(c) Sugar cane (d) Maize

77. 'Sago' (sabudana) is obtained from:
(a) *Borassus flabellifer* (b) *Caryota urens*
(c) *Metroxylon* (d) *Erythroxylon*

78. Betelnut is obtained from:
(a) *Acacia catechu* (b) *Areca catechu*
(c) *Croton tiglium* (d) None of these

79. 'Cocaine' is obtained from:
(a) *Theobroma cocoa* (b) *Erythroxylon coca*
(c) *Cannabis sativa* (d) *Papaver somniferum*

80. Charas (Hashish) is obtained from which part of *Cannabis*:
(a) Female flowering tops and leaves
(b) Male flowering tops and leaves
(c) Both male and female flowering tops
(d) None of the above

81. 'Vanila odour' is obtained from a:
(a) Grass (b) Sedge
(c) Orchid (d) None of these

82. Which is called 'King of spices'?
(a) Cardamom (b) Clove
(c) Cinnamon (d) Black pepper

83. Peppermint is obtained from a member of family:
(a) Labiatae (b) Zingiberaceae
(c) Moraceae (d) Myrtaceae

84. Cloves are: **(MPPMT 1996; AIIMS 2001; BHU 2003)**
(a) Fruits (b) Seeds
(c) Flower buds (d) Flowers

85. Palm oil is obtained from:
(a) *Cocos nucifera* (b) *Borasus*
(c) Toddy palm (d) *Elaeis guineensis*

86. Ylang Ylang oil is obtained from:
(a) *Cymbopogon* (b) *Cananga*
(c) *Lavandula* (d) *Vetiveria*

87. 'Nutmegs' of commerce (spice) belong to genus:
(a) *Eugenia* (b) *Cinnamomum*
(c) *Strychnos* (d) *Myristica*

88. 'Gingelly oil' is obtained from seeds of:
(a) *Arachis hypogea* (b) *Brassica campestris*
(c) *Carthamus tinctorius* (d) *Sesamum indicum*

89. 'Mush-kapoor' is obtained from:
(a) *Cinnamomum camphora* (b) *Elettaria*
(c) *Amomum* (d) *Curcuma*

90. Ganda-Biroza (turpentine oil) is obtained from:
(a) *Citrus reticulata* (b) *Cymbopogon*
(c) *Geranium* (d) *Pinus longifolia*

91. 'Margosa oil' is obtained from:
(a) *Brassica napus* (b) *B. campestris*
(c) *Madhuca indica* (d) *Azadirachta*

92. Chief raw material for paper industry in world is:
(a) Bamboo (b) Sabai grass
(c) Spruce (*Picea*) (d) *Eucalyptus*

93. Maximum content of cellulose is in:
(a) *Pinus* (b) *Picea* (spruce)
(c) Bamboo (d) *Eucalyptus*

94. 'Mandarin oil' is obtained from:
(a) *Citrus reticulata* (b) *Santalum*
(c) *Pelargonium* (d) *Cymbopogon*

95. Source of 'Marijuana' is:
(a) *Erythroxylon* (b) *Cannabis*
(c) *Papaver* (d) *Rauwolfia*

96. Maximum production of tea in India is in:
(a) Assam (b) W. Bengal
(c) H.P. (d) Tripura

97. Which is 'Tree of sorrow'?
(a) *Nyctanthes* (b) *Crocus*
(c) *Butea* (d) *Betula*

98. Silk industry is called:
(a) Apiculture (b) Silviculture
(c) Sericulture (d) Pisciculture

99. 'Bhojpatra' is obtained from: **(BHU 1997)**
(a) Leaves of *Betula* (b) Bark of *Betula*
(c) Leaves of *Butea* (d) Bark of *Picea*

100. Red wood is obtained from:
(a) *Sequoia* (b) *Dalbergia sissoo*
(c) *Adina* (d) *Sideroxylon*

101. Cotton fibres are made of:
(a) Fats (b) Proteins
(c) Cellulose (d) None of these

102. *Colchicum luteum*, a plant is important for its:
(a) Ornamental value (b) Fibre value
(c) Food value (d) Medicinal value

103. An insecticide (Pyrethrum) is obtained from:
(a) *Chrysanthemum marschallii*
(b) *Calandula officinalis*
(c) *Cosmos bipinnatus*
(d) *Zinnia*

104. A powder used for blending coffee for flavour is obtained from roots of:
(a) *Lactuca sativa* (b) *Chrysanthemum officinalis*
(c) *Cichorium intybus* (d) *Colchicum autumnale*

105. A plant which is used as a source of spice as well as a dye:
(a) Turmeric (b) Clove
(c) Cardamom (d) Indigo

106. *Rauwolfia serpentina* (Sarpgandha) belongs to family:
(a) Solanaceae (b) Apocynaceae
(c) Malvaceae (d) Rubiaceae

107. Muscular distrophy is commonly found in poor people as they eat cheap pulses from a plant:
(a) *Vigna mungo* (b) *V. radiata*
(c) *Cajanus cajan* (d) *Lathyrus sativus*

108. Which plant yields fibre, oil and animal food? **(CPMT 2001)**
(a) *Helianthus* (b) *Corchorus*
(c) *Gossypium* (d) *Crotolaria*

109. Mahogany wood is obtained from plant of family:
(a) Rutaceae (b) Meliaceae
(c) Rubiaceae (d) Magnoliaceae

110. An intestinal worm killer drug (santonin) is obtained from flowers of:
(a) *Aloe vera* (b) *Artemisia cina*
(c) *Atropa belladona* (d) *Colchicum*

111. Cheapest high energy fruit crop of India is:
(a) Banana (b) Guava
(c) Apple (d) Mango

112. Which of following provides 3 important ingredients of food, *i.e.*, carbohydrate, fat and proteins?
(a) Groundnut (b) Gram
(c) Castor (d) Mango

113. Vegetables are rich in:
(a) Vitamins and minerals (b) Fats and carbohydrates
(c) Vitamins and fats (d) Vitamins and proteins

114. Turmeric powder is obtained from which part of *Curcuma* plant?
(a) Seed (b) Rhizome
(c) Root (d) Fruit

115. Largest news paper industry is at:
(a) Mysore (b) Lucknow
(c) Nepanagar (d) Delhi

***116.** Bagasse is related to manufacture of:
(a) Resin (b) Gums
(c) Cellulose (d) Cane sugar

117. Cardamon hills are found in:
(a) Kerala (b) W. Bengal
(c) M.P. (d) U.P.

118. Quinine was first discovered in:
(a) Portugal (b) Peru
(c) Poland (d) Central Asia

119. Husk fibres obtained from coconut are:
(a) Copra (b) Coir
(c) Flax (d) Hemp

120. Indian rubber tree (*Ficus elastica*) belongs to family:
(a) Euphorbiaceae (b) Moraceae
(c) Asclepiadaceae (d) Papaveraceae

121. Red squill (raticide) is obtained from :
(a) *Derris* roots (b) *Lonchocarpus* roots
(c) *Urginea* bulb (d) *Chrysanthemum* flower

122. Which is the most important source of food and fodder?
(a) Lichen (b) Cereal
(c) Algae (d) Fungi

123. Most cereal crop plants of the world belong to:
(a) Family Gramineae (b) Family Leguminoseae
(c) Family Solanaceae (d) Family Musaceae

124. The principal cereal crop in India is:
(a) Rice (b) Sorghum
(c) Wheat (d) Maize

125. Wheat plant is botanically known as:
(a) *Oryza sativa* (b) *Triticum vulgare*
(c) *Secale cereale* (d) *Sorghum vulgare*

126. One of the plant introduced from old world to the new world is:
(a) Sweet potato (b) Corn
(c) Potato (d) Rice

127. The carbohydrate rich, edible portion in cereals is:
(a) Seed coat (b) Fruit wall
(c) Embryo (d) Endosperm

128. *Triticum aestivum* is: **(MPPMT 2000)**
(a) Diploid (b) Triploid
(c) Tetraploid (d) Hexaploid

129. The most nutritious cereal is :
(a) Wheat (b) Oat
(c) Maize (d) Rice

130. The botanical name of Bajra is:
(a) *Triticum aestivum* (b) *Pennisetum typhoides*
(c) *Sorghum vulgare* (d) *Zea mays*

131. The first cereals to be domesticated were:
(a) Barley and panicum (b) Wheat and rice
(c) Maize and rye (d) None of these

132. Cereals are rich in: **(MPPMT 1996)**
(a) Carbohydrates (b) Protein
(c) Some fats and vitamins (d) All of these

133. In our country maize is grown as:
(a) Kharif crop (b) Rabi crop
(c) Alternate crop (d) Dry season crop

134. The cereal on which 50% of world population depend for food is:
(a) Wheat (b) Rice
(c) Maize (d) Barley

135. Common protein found in maize is:
(a) Glycine (b) Albumin
(c) Zein (d) None of these

136. The edible portion in millets is:
(a) Thalamus (b) Fruit wall
(c) Seed coat (d) Endosperm

137. One of the following is a gift of new world to old world:
(a) Wheat (b) Maize
(c) Barley (d) Rice

138. Which of the following families provide food rich in carbohydrates?
(a) Cruciferae (b) Leguminosae
(c) Gramineae (d) Palmae

139. The botanical name of finger-millet (Ragi) is:
(a) *Sorghum vulgare* (b) *Eleusine coracana*
(c) *Secale cereale* (d) *Avena sativa*

140. Central Rice Research Institute is situated at:
(a) Shimla (b) Trivandrum
(c) Coimbatore (d) Cuttack

141. The cereal having its centre of origin in West Asia is:
(a) Wheat (b) Rice
(c) Maize (d) Barley

142. The characteristic fruit of family Gramineae is:
(a) Karyopsis (b) Berry
(c) Pepo (d) None of these

143. *Oryza sativa* belongs to:
(a) Solanaceae (b) Liliaceae
(c) Gramineae (d) Araceae

144. One of the major 'Basmati' rice producing states in our country is:
(a) Kerala (b) Uttar Pradesh
(c) Andhra Pradesh (d) Karnataka

145. The one most widely grown or foremost crop of the world is:
(a) Wheat (b) Rice
(c) Maize (d) Barley

146. Wheat grain is a: (MPPMT 1993)
(a) Fruit (b) Seed
(c) Embryo (d) Glume

147. Rice is a:
(a) Cereal (b) Millet
(c) Pulse (d) Spice

148. Improved Indian variety carrying double genes of dwarfness and higher percentage of protein and lysine is:
(a) Sonalika (b) Lerma-Safed
(c) Kalyan (d) Sharbati-Sonara

149. Which of the following is an important Indian millet?
(a) *Sorghum vulgare* (b) *Eleusine coracana*
(c) *Secale cereale* (d) *Pennisetum typhoides*

150. *Secale cereale* is used for the preparation of:
(a) Wine (b) Beer
(c) Both (a) and (b) (d) None of these

151. Emmer wheat is having chromosome number:
(a) 14 (b) 28
(c) 42 (d) 7

152. Oil seed crop is: (BHU 1991)
(a) *Arachis hypogea* (b) *Solanum tuberosum*
(c) *Cajanus cajan* (d) *Triticum aestivum*

153. Which variety of barley has a higher protein content and more suited as food?
(a) Two rowed variety (b) Four rowed variety
(c) Six rowed variety (d) All of these

154. Indian corn is a native of:
(a) North India (b) Tropical South America
(c) Africa and India (d) South Europe

155. Largest area under cultivation is of: (CBSE 1992)
(a) Jute (b) Cotton
(c) Wheat (d) Sugar cane

156. Barley is the common name of:
(a) *Avena sativa* (b) *Hordeum vulgare*
(c) *Pennisetum typhoides* (d) *Sorghum vulgare*

*157. Popcorn is:
(a) *Zea mays* var. *tunicata* (b) *Zea mays* var. *amylacea*
(c) *Zea mays* var. *indentata* (d) *Zea mays* var. *everta*

158. Which of the following has high sugar contents?
(a) Flint corn (b) Dent corn
(c) Sweet corn (d) Waxy corn

159. To get food containing mainly starch we grow:
(a) Rice and wheat
(b) Groundnut and coconut
(c) Cabbage and cauliflower
(d) Grapes and orange

160. Which of the following grains have never been reported from any of the archeological excavations in India?
(a) Wheat (b) Barley
(c) Rice (d) Maize

161. Which variety of barley suits best in the production of malt, whisky, beer and other alcoholic beverages?
(a) Two rowed variety (b) Four rowed variety
(c) Six rowed variety (d) Any of these

162. Which of the following is important rice growing area?
(a) America (b) USSR
(c) China (d) All are equally good

163. Centre of origin of Pearl millet is:
(a) Africa (b) America
(c) China (d) Euresia

164. The tropical cereal is:
(a) Rice (b) Wheat
(c) Pea (d) Buck wheat

165. Which are pseudocereals ?
(a) Sorghum (b) Millets
(c) Buck wheat (d) All of these

166. The millet which can be grown both in Rabi and Kharif season is:
(a) Pearl millet (b) Finger millet
(c) Sorghum (d) All of these

167. Which of the following are true cereals?
(a) Wheat and rice (b) Maize and barley
(c) Rye (d) All of these

168. Food grains which provide the most important staple food for man are:
(a) Oil seeds (b) Millets
(c) Legumes (d) Cereals

169. The common bread wheat is called:
(a) *Triticum aestivum* (b) *Triticum turgidum*
(c) *Triticum monococcum* (d) None of these

170. Which is the most important cereal crop of temperate region?
(a) Maize (b) Barley
(c) Paddy (d) Wheat

171. The millet used in preparation of infant food is:
(a) Prosso millet (b) Finger millet
(c) Pearl millet (d) Foxtail millet

172. The fibres of maize are used in making:
(a) Paper (b) Yarn
(c) Both (a) and (b) (d) None of these

173. Shortest duration rice variety is:
(a) Pusa-215 (b) Sabarmati
(c) Pusa-33 (d) None of these

174. Largest wheat producing country of world is:
(a) USSR (b) USA
(c) India (d) None of these

175. Bran oil is obtained from:
(a) Wheat (b) Maize
(c) Rice (d) Rye

176. What is the botanical name of Buck wheat (Kuttu)?
(a) *Fagopyrum esculentum* (b) *Euryale ferox*
(c) *Chenopodium quinoa* (d) None of these

177. Out of these least protein content is found in:
(a) Wheat (b) Maize
(c) Pea (d) Rice

178. Among the following which one is the richest source of proteins:
(a) Rice
(b) Groundnut (*Arachis hypogea*)
(c) Wheat
(d) Gram

179. Sugar is extracted from sugar cane and also from the crops of:
(a) Potato (b) Sweet potato
(c) Beet (d) Tapioca

180. Which of the following is best suitable for dry farming?
(a) Pearl millet (b) Finger millet
(c) Rice (d) Wheat

181. Which states in India are largest producers of sugar cane?
(a) Bihar and U.P.
(b) U.P. and Rajasthan
(c) Andhra Pradesh and J&K
(d) Punjab

182. The climate best suitable for sugar cane farming is found in:
(a) Punjab (b) Orissa
(c) U.P. (d) Tamilnadu

183. Beet root (*Beta vulgaris*) belongs to family:
(a) Apocynaceae (b) Cruciferae
(c) Chenopodiaceae (d) Asclepiadaceae

184. The common pest which harms the sugar cane crop is:
(a) *Pyrilla perpusila* (b) Termites
(c) Piricularia (d) Locusts

185. Tapioca belongs to:
(a) Euphorbiaceae (b) Chenopodiaceae
(c) Rubiaceae (d) Apocynaceae

186. Botanical name of Cassava is:
(a) *Colocasia esculenta*
(b) *Manihot esculenta*
(c) *Lycopersicum esculentum*
(d) None of the above

187. Potatoes are generally propagated by vegetative means because:
(a) The seeds of potato have long dormancy period
(b) By this method incidence of diseases may be minimised
(c) By this method it is possible to maintain genetic quality
(d) Seeds are not produced by them

188. Sweet potato is a modification of:
(a) Stem (b) Bud
(c) Tap root (d) Adventitious roots

189. Nepanagar is known for: **(AIIMS 1990)**
(a) A news paper industry
(b) A hill station
(c) A city in Himachal Pradesh
(d) A city in Assam

190. The plant, whose pulp is used in paper industry is:
(a) *Bambusa* (b) *Olea*
(c) *Gossypium* (d) *Salmalia*

191. The place where first paper mill was established is:
(a) Baghdad (b) Washington
(c) Tokyo (d) Peking

192. Bamboo grows in:
(a) Temperate evergreen forests
(b) Tropical rain forests
(c) Deciduous forests
(d) Dry deciduous forests

193. Pulse crops belong to family: **(BHU 1991; CBSE 1993)**
(a) Leguminosae (Papilionaceae)
(b) Solanaceae
(c) Malvaceae
(d) Gramineae

194. One of the major foreign exchange earning crops of India is:
(a) Wheat (b) Tea
(c) Rice (d) Coffee

***195.** Non alcoholic beverages contain stimulating property due to the presence of:
(a) Caffeine (b) Atropine
(c) Nimbin (d) Thymol

196. Coffee plant is a native of:
(a) Sri Lanka (b) Abyssinia
(c) China (d) India

197. Largest producer of coffee in the world is:
(a) Brazil (b) Westindies
(c) America (d) None of these

198. Coffee is obtained from:
(a) Flowers (b) Seeds
(c) Leaves (d) Fruits

199. Botanical name of tea is:
(a) *Sinensis thea*
(b) *Sinensis*
(c) *Thea sinensis* Syn. *Camellia sinensis*
(d) *Coffea arabica*

200. Coffee is mainly produced in India in:
(a) Andhra Pradesh (b) Karnataka
(c) Kerala (d) Tamilnadu

201. 'Chicory powder' which is mixed with coffee powder is obtained from: (CBSE 1992; BHU 1999)
(a) Roots (b) Leaves
(c) Seeds (d) Stems

202. One of the plants introduced from the new world to old world is:
(a) Wheat (b) Potato
(c) Rice (d) Sugar cane

203. Arrow-root starch is obtained from:
(a) *Solanum tuberosum* (b) *Oryza sativa*
(c) *Maranta arundinacea* (d) *Metroxylon rumphii*

204. Atmospheric nitrogen in the soil is fixed by:
(a) Cereals (b) Pulses
(c) Sugar cane (d) Cotton

205. Fibres are obtained from:
(a) Chlorenchyma (b) Sclerenchyma
(c) Parenchyma (d) Collenchyma

206. The most widely grown bast fibre plant in India is:
(a) Flax (b) Jute
(c) Hemp (d) Cotton

207. Fibres of great commercial importance derived from epidermis of seed is: **(Raj. PMT 2001)**
(a) Coir (b) Cotton
(c) Flax (d) Hemp

208. Cotton is obtained from:
(a) *Cocos* (b) *Brassica*
(c) *Gossypium* (d) *Arachis*

209. Retting is a process in which?
(a) Enzymes dissolve calcium pectate of middle lamella
(b) Fibres are wooven into threads
(c) Stem is broken into many small pieces
(d) None of the above

210. Which of the following is not a plant fibre?
(a) Flax (b) Coir
(c) Silk (d) Hemp

211. Which of the following is grown as the most important source of textile fibres in West Bengal?
(a) *Linum* (b) *Corchorus* (Jute)
(c) *Crotolaria* (d) *Gossypium*

212. Which state in India leads in cotton production? **(MPPMT 1990)**
(a) Punjab (b) Karnataka
(c) U.P. (d) Gujarat

213. Which one of the following groups of plant produces fibres of economic importance? **(CPMT 1990)**
(a) *Gossypium, Hibiscus, Crotolaria*
(b) *Gossypium, Cassia, Lycopersicum*
(c) *Gossypium, Brassica, Glycine*
(d) *Gossypium, Agave, Nicotiana*

214. The commercial jute fibres are obtained from:
(a) Interxylary fibres (b) Xylem fibres
(c) Phloem fibres (d) None of these

215. Hard fibres are generally obtained from:
(a) Dicot plant (b) Tropical dicot plants
(c) Tropical monocot plants (d) None of these

216. The monocot fibre yielding plant is:
(a) *Clematis* (b) *Corchorus*
(c) *Crotolaria* (d) *Cocos*

217. Which one of the following plants yields sun hemp? **(MPPMT 1995)**
(a) *Cannabis* (b) *Crotolaria*
(c) *Corchorus* (d) *Hibiscus*

218. Semul fibres which are used as filling fibres are obtained from:
(a) *Bombax ceiba* (b) *Calotropis procera*
(c) *Hibiscus elatus* (d) None of these

*219. Long cotton fibres are called: **(MPPMT 1995)**
(a) Lint (b) Flint
(c) Fuzz (d) Coir

220. The fibre crop occupying the largest area in India is:
(a) Cotton (b) Jute
(c) Sisal (d) Flax

221. The main component of jute fibre is:
(a) Cellulose (b) Hemicellulose
(c) Lignin (d) Pectin

222. Which species of *Gossypium* is cultivated maximum in India?
(a) *G. arboreum* (b) *G. hirsutum*
(c) *G. barbadense* (d) None of these

223. Bast fibres are obtained from:
(a) *Gossypium* (b) *Cocos*
(c) *Corchorus* (d) *Agave*

224. Coir of commerce is obtained from:
(a) Mango (b) Litchi
(c) Coconut (d) Plaintain

225. The natural fibres which are toughest, longest, strongest and most durable are of:
(a) Cotton (b) Ramie
(c) Kapok (d) Sisal

226. Which of the following is a fibre yielding plant?
(a) *Cicer arietinum* (b) *Impatiens balsamia*
(c) *Crotolaria juncea* (d) *Triticum vulgare*

227. Husk fibre or Coir of commerce is obtained from which part of coconut (*Cocos nucifera*)? **(Haryana PMT 2001)**
(a) Endocarp (b) Seed coat
(c) Mesocarp (d) Epicarp

228. Instead of jute, we can use:
(a) Hemp (b) Deccan hemp
(c) Manila hemp (d) Sunn hemp

229. Husk fibres obtained from dry coconut are called:
(a) Flax (b) Hemp
(c) Coir (d) Copra

230. Cotton fibres develop from: **(CPMT 1990)**
(a) Fruit wall (b) Testa
(c) Epidermis of seed (d) Pericarp

231. Jute is obtained from the plant which belongs to: **(MPPMT 1995)**
(a) Sterculiaceae (b) Tiliaceae
(c) Euphorbiaceae (d) Malvaceae

232. Hemp fibres are obtained from:
(a) *Cannabis sativa* (b) *Hibiscus*
(c) *Corchorus* (d) *Linum*

233. The flax fibres are obtained from:
(a) *Cocos nucifera* (b) *Linum usitatissimum*
(c) *Cannabis sativa* (d) *Crotolaria juncea*

234. The species of *Gossypium* cultivated least in India is:
(a) *G. arboreum* (b) *G. hirsutum*
(c) *G. barbadense* (d) *G. herbaceum*

235. Which of the following is a fibre yielding plant?
(a) *Cicer arietinum* (b) *Impatiens balsamia*
(c) *Crotolaria juncea* (d) *Triticum vulgare*

236. Cotton fibres are made up of:
(a) Protein (b) Cellulose
(c) Fats (d) Starch

237. The plant which is a source of oil and fibre is:
(a) *Linum usitatissimum* (b) *Gossypium herbaceum*
(c) *Cocos nucifera* (d) All of these

238. A cultivated plant whose seed epidermis produces abundant cellulosic hairs used in textile industry and manufacture of quality paper is:
(a) *Cannabis sativa* (b) *Gossypium herbaceum*
(c) *Linum usitatissimum* (d) *Salmalia malabarica*

239. Jute is obtained from: **(MPPMT 1993)**
(a) Leaves of *Linum* species
(b) Leaves of *Corchorus* species
(c) Secondary phloem of stem of *Corchorus* species
(d) Secondary phloem of stem of *Linum* species

240. Cotton belongs to family: **(CPMT 1993; Pb. PMT 1997)**
(a) Solanaceae (b) Leguminosae
(c) Cucurbitaceae (d) Malvaceae

241. From which part of the cotton plant (*Gossypium*) maximum cellulose fibres can be obtained: **(BHU 1993)**
(a) Root hair (b) Seed hair
(c) Stem surface (d) Leaf surface

242. The fibres associated with phloem are known as: **(MPPMT 1995)**
(a) Hard fibre (b) Wood fibre
(c) Bast fibre (d) Surface fibre

243. An important fibre yielding plant is:
(a) *Corchorus* (b) *Cedrus*
(c) *Fragaria* (d) *Bambusa*

244. Which state of India is the largest producer of jute? **(CBSE 1991; MPPMT 2000)**
(a) Andhra Pradesh (b) West Bengal
(c) Madhya Pradesh (d) Kerala

245. Fibrous cells are: **(AFMC 1993)**
(a) Living
(b) Dead
(c) In some plants they are living
(d) None of the above

246. High tensile strength is of:
(a) Textile fibres (b) Natural fibres
(c) Filling fibres (d) All of these

247. The fibres of which plant are used in making fish net?
(a) *Corchorus* (b) *Gossypium*
(c) *Linum usitattissimum* (d) All of these

248. To which of the following family the flax plant belongs?
(a) Liliaceae (b) Linaceae
(c) Lyraceae (d) Lythraceae

249. Bowstring hemp is obtained from:
(a) *Phormium* (b) *Sensiviera*
(c) *Cocos nucifera* (d) *Areca*

250. The fibre obtained from the leaves of which of the following plants is used for making ropes?
(a) *Erianthus munja* (b) *Saccharum munja*
(c) *Sachharum spontaneum* (d) All of these

251. Manila hemp is obtained from:
(a) Musaceae (b) Liliaceae
(c) Amaryllidaceae (d) Malvaceae

252. New world cotton is said to be:
(a) American cotton (b) Mexican cotton
(c) Egyptian cotton (d) Indian cotton

253. Fibrous mesocarp is present in:
(a) *Cocos nucifera* (b) Mango
(c) Banana (d) None of these

254. Pericycle of which of the plant contains fibre?
(a) Cotton (b) Flax
(c) *Cocos nucifera* (d) All of these

255. Which of the following have large lumen?
(a) Sclerenchyma fibre (b) Stone cells
(c) Fibre trachieds (d) Equal in all

256. Which country leads in the cotton production?
(a) America (b) China
(c) England (d) Africa

257. Which of the following families has fibres producing plants?
(a) Gramineae (b) Malvaceae
(c) Linaceae (d) All of these

258. In plants the skeleton is made up of:
(a) Protein (b) Fat
(c) Cellulose (d) All of these

259. The plant from which 'Broom corn' is obtained is:
(a) *Sorghum* (b) *Attalia*
(c) *Borassus* (d) *Cocos*

260. In hosiery products the cotton used is:
(a) Egyptian cotton (b) Sea-island cotton
(c) American cotton (d) Indian cotton

261. The family from which 'Ramie fibre' is obtained is:
(a) Cruciferae (b) Urticaceae
(c) Leguminosae (d) Tiliaceae

262. Lint and fuzz are features of: (CPMT 1995)
(a) Coir (b) Jute
(c) Cotton (d) Hemp

263. The family Leguminosae is important as the members yield:
(a) Fibres (b) Pulses
(c) Vegetables (d) Oils

264. Widest variety of pulses are grown in:
(a) China (b) Brazil
(c) India (d) America

265. Which of the following have a higher protein contents?
(a) Cereals (b) Millets
(c) Vegetables (d) Pulses

266. The richest source of protein among the following is: (CPMT 1995)
(a) Soybean (b) Moong
(c) Gram (d) Castor

267. The pulse crop is not manured with nitrogenous fertilizers, because their roots are:
(a) Non-nodulated
(b) Nodulated
(c) Unable to utilize nitrogen
(d) Apogeotropic

268. A milk like preparation can be made from the seeds of:
(a) Barley (b) Gram
(c) Soybean (d) Grapes

269. Lobia is:
(a) *Vigna sinensis* (b) *Cajanus cajan*
(c) *Phaseolus radiatus* (d) None of these

270. Which of the following family provides food rich in protein?
(a) Leguminosae (b) Cruciferae
(c) Solanaceae (d) Liliaceae

271. High content of carbohydrate is found in:
(a) Soybean (b) Groundnut
(c) Pea (d) Gram

272. Which of the following pulses is not a native of India?
(a) Gram/*Cicer arietinum*
(b) Black gram/*Phaseolus mungo*
(c) Green gram/*Phaseolus aureus*
(d) All of the above

273. Which of the following differs in its chief economic importance? (CPMT 1993)
(a) *Helianthus annus* (b) *Brassica juncea*
(c) *Allium cepa* (d) *Arachis hypogea*

274. The legume which is cultivated for both proteins and oil is: (CET Chandigarh 1996)
(a) *Glycine max* (b) *Cajanus cajan*
(c) *Cicer arietinum* (d) *Vigna radiata*

275. Groundnut in India is mainly cultivated in : (CBSE 1991, 93)
(a) Gujarat (b) Assam
(c) Bihar (d) Kerala

276. Many vegetables yielding and pulse yielding plants belong to the families:
(a) Solanaceae and Liliaceae
(b) Malvaceae and Compositae
(c) Compositae and Leguminosae
(d) Cucurbitaceae and Leguminosae

277. Tomato and potato are natives of:
(a) China (b) South America
(c) Canada (d) North America

278. Potatoes are borne on:
(a) Main trunk (b) Stems
(c) Stolons (d) Adventitious roots

279. *Lycopersicum esculentum* is the botanical name of:
(a) Cabbage (b) Tomato
(c) Radish (d) Potato

280. Out of the following, the family which yields many commonly used vegetables as well as drug and narcotics is:
(a) Solanaceae (b) Malvaceae
(c) Cruciferae (d) Compositae

281. Which of the following is called earth vegetable?
(a) *Solanum melongena* (b) *Allium cepa*
(c) *Solanum nigrum* (d) All of these

282. Ginger is a:
(a) Bulb (b) Tuber
(c) Rhizome (d) Corm

283. For sowing potato, the part used is:
(a) Tubers (b) Seed
(c) Leaf (d) Stolons

284. Those plants whose bulb is of economical importance, are generally propagated by vegetative means because: (CBSE 1991)
(a) It is cheaper
(b) It is more economical
(c) The pulp quality remains same
(d) The pulp quality become better

285. Which part of cauliflower is edible?
(a) Stem
(b) Root
(c) Undeveloped fleshy inflorescence
(d) None of the above

286. Which are the important varieties of potato in India?
(a) Kufri Alankar (b) Chandramukhi
(c) Military special (d) All of these

287. Which of the following is egg plant?
(a) *Artocarpus* (b) *Cucurbita*
(c) *Hibiscus esculentus* (d) *Solanum melongena*

288. Which of these is used as earth vegetable? (EAMCET 1990)
(a) *Beta vulgaris* (b) *Daucus*
(c) *Raphanus* (d) All of these

***289.** The dried fruit used for making musical instruments is:
(a) Snake gourd (b) Bitter gourd
(c) Bottle gourd (d) All of these

290. Turnip belongs to family:
(a) Cruciferae (b) Convolvulaceae
(c) Rubiaceae (d) Apocynaceae

291. The salad plant is:
(a) *Lactuca* (b) *Cucumis*
(c) *Asparagus* (d) Tomato

292. The good source of vitamin-A is:
(a) *Beta* (b) *Raphanus*
(c) *Daucus* (d) All of these

293. Leafy vegetables are important because:
(a) They are rich in proteins
(b) They are rich in carbohydrates
(c) They are rich in vitamins and minerals
(d) None of the above

294. The cucurbit having bitter taste and having medicinal value is:
(a) *Cucurbita maxima* (b) *Cucurbita pepo*
(c) *Momordica charantia* (d) None of these

295. Which is the most important cash crop?
(a) *Solanum tuberosum* (b) *Solanum melongena*
(c) *Solanum nigrum* (d) *Solanum xanthocarpum*

296. Among the following, the richest source of vitamin-A is: **(MPPMT 1991)**
(a) Cucumber (b) Egg plant
(c) Bitter gourd (d) Tomato

297. Garlic is used as:
(a) Vegetable (b) Salad
(c) Condiment (d) All of these

298. Among the following which is used as leaf vegetable?
(a) *Chenopodium* (b) *Trigonella*
(c) Spinach (d) All of these

299. Among the following which one is called fruit vegetable?
(a) *Lagenaria* (b) *Citrullus vulgaris*
(c) *Cucumis sativus* (d) All of these

300. *Rauwolfia serpentina* belongs to family:
(a) Malvaceae (b) Rubiaceae
(c) Apocynaceae (d) Solanaceae

301. The drug 'artimisnin' is obtained from:
(a) Bark (b) Leaves
(c) Flower or (Floral buds) (d) Tuberous roots

302. Tobacco leaves contain:
(a) Capscin (b) Colchicine
(c) Nicotine (d) Aspirin

303. 'Strychnine' which is of medicinal importance is essentially:
(a) An antimalarial drug
(b) An alkaloid from *Strychnos nux-vomica*
(c) An anti hypertension drug
(d) An antibiotic drug

304. Narcotic and soothing properties of tobacco is due to:
(a) Aconite (b) Codeine
(c) Caffeine (d) Nicotine

305. Saffron plants belong to family:
(a) Iridaceae (b) Araceae
(c) Zingiberaceae (d) Liliaceae

306. Medicine to check high blood pressure is obtained from:
(a) *Digitalis* (b) *Cinchona* sps.
(c) *Rauwolfia* sps. (d) None of these

307. Which of the following plant yields the drug belladona? **(MPPMT 2001)**
(a) *Papaver somniferum* (b) *Atropa belladona*
(c) *Phoenix sylvestris* (d) *Acacia arabica*

308. One of the following is a plant of great medicinal value:
(a) *Rauwolfia serpentina*
(b) *Brassica oleracea*
(c) *Cryptostegia grandiflora*
(d) *Coffea robusta*

309. Which of the following is a medicinal plant?
(a) *Aconitum* (b) *Tectona*
(c) *Dalbergia* (d) *Linum*

***310.** Which part of *Ephedra* plant yields the drug ephedrine? **(MPPMT 1994)**
(a) Root (b) Stem
(c) Leaf (d) Flowers

311. From which part of *Atropa belladona* the drug 'belladona' is obtained?
(a) Leaves (b) Roots
(c) Stems (d) All the parts of the plant

312. Stramonium drug is obtained from the plant species of: **(MPPMT 1994)**
(a) *Ocimum* (b) *Rauwolfia*
(c) *Datura* (d) *Asphodelus*

313. Opium is a plant belonging to family:
(a) Apocynaceae (b) Euphorbiaceae
(c) Papaveraceae (d) None of these

314. The alkaloid colchicine is obtained from:
(a) Dried corm of *Colchicum*
(b) Dried flowers of *Colchicum*
(c) Dried seeds of *Colchicum*
(d) All of the above

315. Alkaloid codeine is obtained from:
(a) *Papaver somniferum* (b) *Emblica officinalis*
(c) *Withania somnifera* (d) *Rauwolfia serpentina*

316. *Salvia officinalis* which is used in lung T.B. belongs to family: **(MDAT Bihar 1990)**
(a) Labiatae (b) Acanthaceae
(c) Euphorbiaceae (d) Apocynaceae

317. Ayurvedic drug 'asgandh' is obtained from:
(a) *Cassia* (b) *Withania*
(c) *Atropa* (d) *Petunia*

318. Which of the following oil may be used in mental weakness?
(a) Linseed oil (b) Mustard oil
(c) Almond oil (d) Til oil

319. Which has narcotic property? **(EAMCET 1990)**
(a) Charas (b) Bhang
(c) Ganja (d) All of these

320. Brahmi is an important tonic for:
(a) Brain (b) Body
(c) General health (d) None of these

321. For curing the children who urenate in sleep, the leaves used are of:
(a) *Smilax* (b) *Withania*
(c) *Atropa* (d) None of these

322. Atropine used for eye testing is obtained from:
(a) *Aloe* (b) *Erythroxylon*
(c) *Rauwolfia* (d) Belladona

*323. Heroin is obtained from the plant of: (MPPMT 1994)
(a) Poppy (b) Tobacco
(c) *Datura* (d) *Cannabis* sps.

324. The drug plant *Aconitum napellus* belongs to the family: (MPPMT 1995)
(a) Ranunculaceae (b) Apocynaceae
(c) Papaveraceae (d) Solanaceae

325. In purifying blood, the plant used is:
(a) *Emblica* (b) Opium
(c) *Citrus* (d) *Atropa*

326. From which part of *Cinchona* a drug is obtained ? (MPPMT 1995)
(a) Pericarp (b) Endosperm
(c) Leaf (d) Bark

327. Which of the following plant yields the medicine used for pupil dilation?
(a) *Allium cepa* (b) *Colchicum*
(c) *Atropa* (d) *Rauwolfia*

328. LSD is obtained from: (MPPMT 1995)
(a) *Rauwolfia* (b) *Cinchona*
(c) *Cannabis* (d) *Claviceps*

329. Colchicine is used in curing:
(a) Stomach pain (b) Tooth pain
(c) Joint pain (d) Headache

330. Medicines used for curing impotancy are made by:
(a) *Acacia arabica* (b) *Rauwolfia serpentina*
(c) *Asparagus racemosa* (d) *Withania somenifera*

331. Alkaloid barberine is obtained from:
(a) *Berberis aristata* (b) *Brassica oleracea*
(c) *Withania somnifera* (d) *Atropa belladona*

332. Gymnospermic plant having medicinal use is:
(a) *Thuja occidentalis* (b) *Areca catechu*
(c) *Saponaria* (d) *Cycas*

333. In the preparation of pain relieving drug the plant used is:
(a) *Aconitum* (b) Belladona
(c) *Withania* (d) All of these

334. Drug 'hyoscyamine' is obtained from:
(a) *Atropa* (b) *Withania*
(c) *Nicotiana* (d) *Cassia*

335. Sugar cane juice contains: (CPMT 1992)
(a) Sucrose only
(b) Sucrose + maltose
(c) Sucrose + pectose + lactose
(d) Maltose

336. *Rauwolfia serpentina* which belongs to Apocynaceae yields medicine of:
(a) Blood pressure (b) Nervousness
(c) Insomnia (d) All of these

337. Toothache is cured by the use of:
(a) *Capsicum annum* (b) *Jatropha gossypifolia*
(c) *Vanda parviflora* (d) None of these

338. Nux-vomica tree belongs to genus:
(a) *Emblica* (b) *Ferula*
(c) *Strychnos* (d) None of these

339. Clove oil is obtained from:
(a) Leaves of *Syzygium aromaticum*
(b) Flower buds of *Syzygium aromaticum*
(c) Rhizome of *Vetiveria*
(d) Wood of *Santalum*

340. The wood having good quality of essential oil is:
(a) *Shorea robusta* (b) *Areca catechu*
(c) *Santalum album* (d) *Feronia elephantum*

341. Which of the following drupe fruit produces oily endosperm?
(a) Mango (b) *Cocos nucifera*
(c) Both (a) and (b) (d) None of these

342. Peanut oil is obtained from:
(a) *Lathyrus odoratus* (b) *Pisum sativum*
(c) *Arachis hypogea* (d) *Glycine max*

343. Which of the following oil is used in the preparation of typewriter ink? (EAMCET 1990)
(a) *Linum* oil (b) *Brassica* oil
(c) Chir oil (d) None of these

344. Edible oil is obtained from the endosperm of: (CPMT 1994)
(a) Coconut (b) Mustard
(c) Groundnut (d) Soybean

345. In groundnut the oil is present in: (MPPMT 1995)
(a) Endosperm (b) Embryo
(c) Nucellus (d) Fruit

346. Which of the following is oldest cultivated fruit crop of world?
(a) Apple (b) Guava
(c) Banana (d) Mango

347. 'Plantain' means:
(a) Banana plant (b) Ripe banana
(c) Unripe banana (d) None of these

348. Commercially important species of *Nicotiana* are:
(a) *N. rustica* (b) *N. tabaccum*
(c) Both (a) and (b) (d) None of the above

349. Banana reproduces or cultivated through: (CBSE 1990)
(a) Underground suckers (b) Rhizomes
(c) Seeds (d) Stolons

350. Which of the following is an edible mushroom?
(a) *Agaricus campestris* (b) *Morchella esculenta*
(c) Both (a) and (b) (d) None of these

351. The edible portion of banana is:
(a) Pericarp (b) Mesocarp
(c) Endosperm (d) Cotyledon

352. Which of the following provides delicious drink with laxative and diuretic property?
(a) Cashewnut (b) Arecanut
(c) Coconut (d) None of these

353. Which of the following fruit is a native of India?
(a) Guava (b) Apple
(c) Pineapple (d) Mango

354. Teak wood is obtained from:
(a) *Tectona grandis* (b) *Thuja*
(c) *Terminalia* (d) *Tamarindus*

355. Which of the following yields valuable timber? **(CPMT 1991)**
(a) *Acacia arabica* (b) *Dalbergia sissoo*
(c) *Mangifera indica* (d) *Prosopis spicegera*

356. Sal wood is obtained from:
(a) *Salmalia malabarica* (b) *Shorea robusta*
(c) *Dalbergia sissoo* (d) *Tectona grandis*

357. In India hockey sticks are generally made from:
(a) *Melia* (b) *Morus alba*
(c) *Morus nigra* (d) *Salix*

358. The source of Indian iron wood is:
(a) *Areca catechu* (b) *Xylia xylocarpa*
(c) *Azadirachta indica* (d) None of these

359. The wood which is very costly and having commercial significance is:
(a) Chir (b) Sheesham
(c) Chandan (d) Teak

360. Commercial cork is obtained from the member of family: **(EAMCET 1990)**
(a) Moraceae (b) Fabaceae
(c) Fagaceae (d) All of these

361. Important commercial wood is obtained from:
(a) *Ficus religiosa* (b) *Juglans regia*
(c) *Tectona grandis* (d) *Mangifera indica*

***362.** Wood is obtained from:
(a) Primary xylem of angiosperms
(b) Primary xylem of gymnosperms
(c) Secondary xylem of angiosperms and gymnosperms
(d) None of the above

363. Oil used in eczema and ring worm is obtained by the wood distillation of:
(a) *Tectona grandis* (b) *Vanda parviflora*
(c) *Santalum album* (d) *Shorea robusta*

364. Catechu is obtained from the:
(a) Leaf of *Acacia* (b) Seeds of *Acacia*
(c) Wood of *Acacia* (d) Roots of *Acacia*

365. Rubber is obtained from: **(BHU 1995)**
(a) *Ficus elastica* (b) *Castilla elastica*
(c) *Hevea brasiliensis* (d) *Michelia champaca*

366. Among following which wood is commercially superior?
(a) Sagwan (b) Sheesham
(c) Sal (d) Chir

367. Botanical name of cardamom is:
(a) *Pisum sativum* (b) *Elettaria cardamomum*
(c) *Cinchona officinale* (d) None of these

368. Manuscripts were written on the bark of: **(CPMT 1994)**
(a) *Betula* (b) *Cinchona*
(c) *Pinus* (d) None of these

369. Which of the following oil is golden yellow in colour?
(a) Oil of castor (b) Sunflower oil
(c) Olive oil (d) All of these

370. Fatty oils are of:
(a) Drying type (b) Semi drying type
(c) Non drying type (d) All of these

371. Hemp oil is obtained from which part of the plant?
(a) Leaf (b) Roots
(c) Seeds (d) Flowers

372. Which of the following are called fixed oils?
(a) Essential oils (b) Fatty oils
(c) Both (a) and (b) (d) None of these

373. Perilla oil is obtained from the plant belonging to family:
(a) Labiatae (b) Liliaceae
(c) Leguminosae (d) Gramineae

374. The plant yielding turpentine oil is:
(a) *Eucalyptus* (b) *Pinus longifolia*
(c) *Melia azadirachta* (d) *Shorea robusta*

375. The leaves of which plant are used as mosquito repellent?
(a) *Eucalyptus* (b) *Melia azadirachta*
(c) *Vanda parviflora* (d) *Acacia arabica*

376. Oils are used for preparation of:
(a) Vegetable ghee (b) Soap
(c) Both (a) and (b) (d) None of these

377. Lemon-grass oil is extracted from: **(AMU 1997)**
(a) *Bambusa beecheyana* (b) *Cymbopogon citratus*
(c) *Cymbopogon nardus* (d) *Cymbopogon martinii*

378. Essential oils are those which are: **(CBSE 1992)**
(a) Used in soap manufacture
(b) Used in perfumes
(c) Essential for plants producing them
(d) Essential for human beings

379. In extracting oil from the sandal wood which part of the plant is used?
(a) Leaf (b) Wood
(c) Bark (d) Flower

380. *Carthamus tinctorius* belongs to the family: **(St. John's 1993)**
(a) Compositae (b) Solanaceae
(c) Malvaceae (d) Apocynaceae

381. Oil yielding plants are abundant in the family:
(a) Solanaceae (b) Ranunculaceae
(c) Cruciferae (d) Cucurbitaceae

382. Sunflower is principally cultivated for its:
(a) Oil (b) Alkaloid
(c) Starch (d) Protein

383. Castor oil plants *(Ricinus communis)* belongs to family:
(a) Palmae (b) Euphorbiaceae
(c) Compositae (d) Cruciferae

384. Asafoetida is a/an:
(a) Resin (b) Gum
(c) Olio-gum-resin (d) None of these

385. Poppy oil is used as edible oil even if the plant is having narcotic properties and oil has:
(a) Normal oily property (b) Narcotic property
(c) Highly narcotic (d) None of these

386. In paints and varnishes the oil used is:
(a) Linseed oil (b) Tung oil
(c) Soybean oil (d) All of these

387. Which of the oil cake is used in the preparation of sweets?
(a) Sunflower (b) Coconut
(c) Cotton seed oil (d) None of these

388. Oil used as a clearing agent in histological work is:
(a) Clove oil (b) Tung oil
(c) Linseed oil (d) Soybean oil

389. Which of the following is not an essential oil? **(MPPMT 1990)**
(a) Clove oil (b) Eucalyptus oil
(c) Sandal wood oil (d) Groundnut oil

390. The leather lubricant oil is:
(a) Castor seed oil (b) *Brassica* oil
(c) Linseed oil (d) Cotton seed oil

391. Among these the drying oil is:
(a) Walnut oil (b) Soybean oil
(c) Linseed oil (d) All of these

392. Groundnut oil is a: (MPPMT 1993)
(a) Non drying oil (b) Essential oil
(c) Drying oil (d) None of these

393. Which of the following pairs of plants gives oil and fibres both? **(CPMT 1992)**
(a) *Gossypium* and *Brassica*
(b) *Brassica* and *Linum usitatissimum*
(c) Cotton, flax
(d) Sunflower and *Brassica*

394. Corn oil is obtained from:
(a) Embryo (b) Endosperm
(c) Leaf (d) Flowers

395. Following are the oil yielding plants except: **(CPMT 1993)**
(a) *Arachis hypogea* (b) *Brassica campestris*
(c) *Gossypium cannabinus* (d) *Allium cepa*

396. Oil cake of which plant is used as cattle feed and biofertilizer:
(a) Sarson (b) Sunflower
(c) Groundnut (d) Castor

397. Eau de cologne is prepared from the flowers of:
(a) *Lavendula* sps. (b) *Jasminum* sps.
(c) Rose (d) None of these

398. For repelling insects, the citronella oil is used which is obtained from:
(a) *Cymbopogon citratus* (b) *Adhatoda vesica*
(c) *Cymbopogon nardus* (d) *Aconitum napellus*

399. Which one of the following is an oil seed crop? **(CBSE 1993)**
(a) Marigold (b) Chrysanthemum
(c) Rose (d) Sunflower

400. At room temperature the peppermint oil is:
(a) Liquid (b) Semisolid
(c) Solid (d) None of these

401. Which of the following is not a source of drug?
(a) *Aconitum napellus* (b) *Dalbergia sissoo*
(c) *Papaver somniferum* (d) *Cannabis sativus*

402. Which of the following is a medicinal plant?
(a) *Aconitum* (b) *Tectona*
(c) *Dalbergia* (d) *Linum*

403. Nux-vomica is used in:
(a) Asthma (b) Nervous disorders
(c) Cough (d) All of these

404. *Carum copticum* (Ajwain) seeds are antispasmodic seeds because they contain:
(a) Thymol (b) Atropine
(c) Theine (d) Caffeine

405. A tree which is introduced in Social Forestry programme in India is:
(a) *Acacia arabica* (b) *Leucaena leucocephala*
(c) *Salix* (d) *Eucalyptus*

406. Which part of *Ephedra* plant yields the drug 'ephedrine'? **(MPPMT 1994)**
(a) Root (b) Stem
(c) Leaf (d) Flowers

407. In diabetes the leaves of which plant are used?
(a) *Strychnos* (b) Opium
(c) *Gymnema sylvestris* (d) *Rauwolfia*

408. Spices are added to the food as:
(a) They have high nutritive value
(b) They increase appetite
(c) They add flavour to food and increase the flow of gastric juices
(d) Both (b) and (c)

409. Which is the new world spice that has become an essential part of Indian cuisine? **(CBSE 1995)**
(a) Red pepper (b) Cardamon
(c) Ginger (d) Black pepper

410. Among the following which oil is semidrying?
(a) Sesame oil (b) Cotton seed oil
(c) Corn oil (d) All of these

411. Largest producer of black pepper is:
(a) India (b) Sri Lanka
(c) Zangibar (d) Siam

412. Non drying oil is:
(a) Olive oil (b) Groundnut oil
(c) Castor oil (d) All of these

413. Cane is obtained from *Calamus rotang*, it is a:
(a) Tree (b) Climbing palm
(c) Trailer (d) Shrub

414. *Cinchona* bark has which of the following alkaloids?
(a) Quinine (b) Cinchonine
(c) Cinchonidine (d) All of these

415. Which of the following statement is not true about saffron or kesar?
(a) It is cultivated in Kashmir
(b) It is dried stigma and top of style

(c) It is used as spice and dye stuff
(d) Saffron is insoluble in water

416. Mathematical instruments are made of the following wood:
(a) *Shorea robusta* (b) *Juglans regia*
(c) *Tectona grandis* (d) *Dalbergia sissoo*

417. Scopolamine alkaloid is obtained from:
(a) *Eucalyptus* (b) *Digitalis*
(c) *Datura stramonium* (d) None of these

418. *Glycyrrhiza glabra* belongs to family:
(a) Convolvulaceae (b) Leguminosae
(c) Myrtaceae (d) None of these

419. Largest producer of groundnut is :
(a) Brazil (b) India
(c) USSR (d) USA

420. Which of the following are nuts?
(a) *Juglans regia* (b) *Prunus amygdalus*
(c) *Pistasia vera* (d) All of these

*421. For the treatment of rheumatism, 'Meetha Jahar' is used, it is obtained from:
(a) *Aconitum napellus* (b) *Exogonium*
(c) *Colchicum* (d) *Gnetum*

422. Cinnamon is obtained from:
(a) *Coriandrum sativum* (b) *Cinnamomum zeylanicum*
(c) *Capsicum annum* (d) *Eugenia caryophyllata*

423. Chief cashewnut producing state of India is:
(CPMT 1994)
(a) Orissa (b) Andhra Pradesh
(c) Assam (d) Kerala

424. Fruit pulp of which plant is used in diarrhoea treatment?
(a) *Shorea robusta* (b) *Mangifera indica*
(c) *Carica papaya* (d) All of these

425. One of the following is most useful to man:
(a) Coconut (b) Jute
(c) Cotton (d) Sunflower

426. Which of the following is the source of chewing gum?
(a) Fluid from *Musa paradisiaca*
(b) Latex from *Achras zapota*
(c) Sugar from sugar cane
(d) Gum arabic from *Acacia* sps.

427. The plant having purgative properties is:
(a) *Exogonium* (b) *Aconitum*
(c) *Lycoris* (d) None of these

428. Cocoa (*Theobroma cacao*) of Sterculiaceae is actually obtained from:
(a) Bark (b) Root
(c) Leaf (d) Seeds

429. Isabgol is made from the bark of:
(a) *Plantago ovata* (b) *Glycyrrhiza glabra*
(c) *Papaver somniferum* (d) *Betula utillis*

430. Which part of *Aconitum napellus* is of medicinal value?
(MPPMT 1993)
(a) Root (b) Stem
(c) Flower buds (d) Leaves

431. Botanical name of mulehthi is:
(a) *Colchicum autumnale* (b) *Allium cepa*
(c) *Glycyrrhiza glabra* (d) *Rauwolfia serpentina*

432. A blue dye indigo is obtained from the plant:
(a) *Indigofera tinctoria* (b) *Crocus sativus*
(c) *Curcuma domestica* (d) None of these

433. In cashewnut the part eaten is:
(a) Whole fruit (b) Seeds
(c) Swollen peduncle (d) None of these

434. The characteristic flavour and bitter taste of beer is produced by adding bud of:
(a) Cocoa plant (b) Pepper plant
(c) Neem plant (d) Hop plant

435. In *Acacia catechu* the part of the plant which yields brown dye is:
(a) Leaves (b) Roots
(c) Heart wood (d) Flowers

436. 'Tree of Sorrow' is:
(a) *Carthamus tinctorius* (b) *Nyctanthes arbortristis*
(c) *Crocus sativus* (d) *Glycyrrhiza glabra*

437. Camphor is obtained from which part of the plant?
(a) Leaves (b) Flowers
(c) Wood (d) None of these

438. In Date-palm edible part is:
(a) Endosperm (b) Pulpy pericarp
(c) Epicarp (d) Mesocarp

439. A dye obtained from the bark of *Terminalia tomentosa* is:
(a) Red in colour (b) Black in colour
(c) Yellow in colour (d) Brown in colour

440. Which of the following plants are used as spices and is obtained from the underground parts?
(a) *Curcuma longa* (b) *Zingiber officinale*
(c) *Ferula asafoetida* (d) All of these

441. From which of the following parts of the plant, the oil is produced?
(a) Roots (b) Seeds
(c) Wood (d) All of these

442. 'Zavitri' is obtained from:
(a) Seeds of *Myristica* (b) Fruits of *Myristica*
(c) Aril of *Myristica* (d) None of these

443. An accessory fruit, the entire fruit, wall fleshy composed of pericarp and floral tube is called:
(a) Berry (b) False berry
(c) Drupe (d) Pome

444. The rind of which fruit contains oil glands?
(a) Castor (b) Coriander
(c) Citrus (d) Mulberry

445. Liquid endosperm of coconut contains:
(a) Auxin (b) Kinetin
(c) Gibberellin (d) ABA

Match the following (Q. 446–450)

446. I. Sarpgandha
II. Opium
III. Santonin
IV. Datura
A. *Artemisia cina*
B. *Papaver somniferum*

C. *Datura stramonium*
D. *Rauwolfia serpentina*
(a) I-D, II-B, III-A, IV-C (b) I-B, II-A, III-C, IV-D
(c) I-A, II-B, III-C, IV-D (d) I-D, II-C, III-B, IV-A

447. I. Cork
II. Sal
III. Kesar
IV. Laung
A. *Shorea robusta*
B. *Crocus sativus*
C. *Eugenia aromaticum*
D. *Quercus suber*
(a) I-A, II-C, III-B, IV-D (b) I-D, II-A, III-B, IV-C
(c) I-C, II-A, III-B, IV-D (d) I-D, II-B, III-A, IV-C

448. I. Red wood
II. Balsa
III. Rose wood
IV. Willow
A. *Sequoia sempervirens*
B. *Ochroma pyramidale*
C. *Salix nigra*
D. *Dalbergia nigra*
(a) I-B, II-A, III-C, IV-D (b) I-A, II-B, III-C, IV-D
(c) I-A, II-B, III-D, IV-C (d) I-D, II-A, III-B, IV-C

449. I. Yams
II. Lettuce
III. Sweet potato
IV. Bread fruit
A. *Ipomea batatus*
B. *Lactuca sativa*
C. *Artocarpus altilis*
D. *Dioscorea alata*
(a) I-D, II-B, III-A, IV-C (b) I-D, II-A, III-C, IV-B
(c) I-B, II-A, III-C, IV-D (d) I-A, II-B, III-C, IV-D

450. I. Aconite
II. Ergot
III. Jalap
IV. Colchicum
A. *Colchicum autmnale*
B. *Claviceps purpurea*
C. *Exogonium purga*
D. *Aconitum napellus*
(a) I-A, II-D, III-B, IV-C (b) I-A, II-C, III-B, IV-D
(c) I-A, II-B, III-C, IV-D (d) I-D, II-B, III-C, IV-A

451. The botanical name of black gram is: **(Manipal 1997)**
(a) *Vigna mungo* (b) *Vigna radiata*
(c) *Vigna aconitifolius* (d) *Lens esculentum*

452. Highest protein content is in: **(CET Chandigarh 1996)**
(a) Wheat seeds (b) Barley seeds
(c) Gram seeds (d) Groundnut seeds

453. Botanical name of 'rai' or Indian mustard is:**(AMU 1997)**
(a) *Brassica juncea* (b) *Brassica nigra*
(c) *Brassica alba* (d) *Brassica campestris*

454. Plant that is commercially called rose wood is: **(BHU 1997)**
(a) *Indigofera tinctoria* (b) *Dalbergia latifolia*
(c) *Crotolaria juncea* (d) *Erythrinia indica*

455. Congress grass is: **(AFMC 1997; CET Chandigarh 1997)**
(a) *Parthenium hysterophorus*
(b) *Cymbopogon citratus*
(c) *Cynodon dactylon*
(d) *Digitaria purpurea*

456. Of the following which one is cultivated for carbohydrates, proteins and fats: **(DPMT 1997)**
(a) *Arachis hypogea* (b) *Cajanus cajan*
(c) *Cicer arietinum* (d) *Ricinus communis*

457. Ganja and LSD are classified in: **(AFMC 1997)**
(a) Narcotic (b) Hallucinogens
(c) Stimulants (d) Depressent

458. Berch is obtained from: **(CPMT 1997)**
(a) *Betula* (b) *Eucalyptus*
(c) Guava (d) Mango

459. Epidermal seed fibres are obtained from: **(CPMT 1997)**
(a) Cotton (b) Coconut
(c) *Crotolaria juncea* (d) None of these

460. Which of the following is the hardest wood? **(BHU 1997)**
(a) *Shorea robusta* (b) *Tectona grandis*
(c) *Cedrus deodara* (d) *Dalbergia sissoo*

461. Which one of the following is an Indian medical plant? **(CBSE 1996)**
(a) *Oryza sativa* (b) *Solanum melongena*
(c) *Rauwolfia serpentina* (d) *Saccharum officinarum*

462. Which part of the coconut produces coir? **(CBSE 1996; BHU 1999; MPPMT 1999)**
(a) Seed coat (b) Pericarp
(c) Mesocarp (d) Epicarp

463. Coffee plant belongs to:
(a) Sterculiaceae (b) Rubiaceae
(c) Annonaceae (d) Cruciferae

464. Which of the following is a source of textile fibre?
(a) *Crotolaria juncea* (b) *Gossypium herbaceum*
(c) *Hibiscus cannabinus* (d) *Cassia occidentalis*

465. Noodles are prepared from: **(Rohtak PMT 1994)**
(a) *Triticum aestivum* (b) *Triticum durum*
(c) *Pennisetum typhoides* (d) *Sorghum vulgare*

466. Which of the following plant is used for preparing malt?
(a) Lemon (b) Rice
(c) Wheat (d) Barley

***467.** Which of the following is called 'Dhan ka katora' of M.P.? **(MPPMT 1996)**
(a) Gwalior (b) Indore
(c) Chattisgarh (d) None of these

468. Which one yields resin, timber and pulp? **(DPMT 1996)**
(a) *Dalbergia* (b) *Quercus*
(c) *Pinus* (d) *Eucalyptus*

469. In India groundnut in mainly cultivated in: **(CPMT 1996)**
(a) Gujarat (b) Bihar
(c) U.P. (d) Rajasthan

470. 'Nagkesar' is obtained from the flowers of: **(MPPMT 1997)**
(a) *Mesua ferrea* (b) *Crocus sativus*
(c) *Viola Odorata* (d) *Centella asiatica*

471. In which state is the coir industry concentrated? **(MPPMT 1997)**
(a) Maharashtra (b) Tamilnadu
(c) Karnataka (d) Kerala

472. Cultivated cotton is obtained from: **(MPPMT 1997)**
(a) Two species (b) Three species
(c) Four species (d) One species

473. The botanical name of jute is: **(MPPMT 1997)**
(a) *Linum usitatissimum* (b) *Corchorus capsularis*
(c) *Hibiscus sabdariffa* (d) *Crotolaria juncea*

474. Margarine is prepared from: **(MPPMT 1997)**
(a) Groundnut (b) Coconut
(c) Almond (d) Cashewnut

475. *Cicer arietinum* is known as:
(a) Black gram (b) Green gram
(c) Bengal gram (d) Dew gram

476. An important medicine for bronchitis is obtained from: **(MPPMT 1997)**
(a) *Adhatoda vasica* (b) *Curcuma longa*
(c) *Hemidesmus indicus* (d) *Rauwolfia serpentina*

477. Opium is a product: **(CPMT 1998)**
(a) Latex (b) Resin
(c) Alkaloid (d) Pigment

478. *Gossypium hirsutum* is: **(CPMT 1999)**
(a) Old world crop and diploid
(b) Old world crop and tetraploid
(c) New world crop and diploid
(d) New world crop and tetraploid

479. Reserpine drug is obtained from: **(MPPMT 1999; Raj. PMT 2002)**
(a) *Rauwolfia serpentina* (b) *Withania somnifera*
(c) *Atropa belladona* (d) *Papaver someniferum*

480. The medicinally most important part of *Rauwolfia serpentina* is: **(MPPMT 1999)**
(a) Root (b) Rhizome
(c) Aerial stem (d) All of these

*481. A person is lacking rhodopsin. Which of the following fruits should be taken? **(CBSE 2000)**
(a) Papaya and mango (b) Papaya and orange
(c) Amla and lemon (d) Amla and orange

482. The cotton of commerce is: **(CPMT 2000; MPPMT 2000)**
(a) Outgrowth of seed coat (b) Outgrowth of capsule
(c) Outgrowth of thalamus (d) None of these

483. Which of the following is most important source of food? **(MPPMT 2000)**
(a) Lichens (b) Angiosperms
(c) Algae (d) Fungi

484. Which of the following is a pseudocereal?
(a) *Triticum aestivum* (b) *Oryza sativa*
(c) *Zea mays* (d) *Fagopyrum esculentum*

485. Which of the following is rich source of protein? **(MPPMT 2000)**
(a) Rice (b) Wheat
(c) Groundnut (d) Pearl millet

486. Which of the following is surface fibre? **(MPPMT 2000)**
(a) Coir (b) Cotton
(c) Sunhemp (d) Manila hemp

487. Which of the following is not a plant fibre? **(MPPMT 2000)**
(a) Cotton (b) Coir
(c) Sunhemp (d) Silk

488. Which of the following is an oil seed crop? **(MPPMT 2000)**
(a) *Coreopsis* (b) Paddy
(c) Sunflower (d) *Chrysanthemum*

489. Richest source of carbohydrate is: **(MPPMT 2000)**
(a) Sorghum (b) Groundnut
(c) Gram (d) Wheat

490. The study of action of drugs is known as: **(MPPMT 2001)**
(a) Pharmacognosy (b) Pharmacology
(c) Physicology (d) Pharmaceutical chemistry

491. In which part of the plant, groundnut oil is stored? **(MPPMT 2000)**
(a) Leaf (b) Tuber
(c) Cotyledon (d) Root

*492. Which of the following are Hallucinogens? **(CET Karnataka 2000)**
(a) Ganja and charas (b) Opium and heroin
(c) Rum and whisky (d) None of these

493. Before the European invader which vegetable was absent in India? **(CBSE 2001)**
(a) Potato and tomato (b) Shimla mirch and brinjal
(c) Maize and chichinda (d) Bitter gourd

494. Which one of the following is correct match? **(CBSE 2001)**
(a) Reserpine—Tranquilliser
(b) Cocaine—Opiatic narcotic
(c) Morphine—Hallucinogenic
(d) Bhang—Analgesic

495. Edible part of cauliflower is: **(AIIMS 2000)**
(a) Bud (b) Leaves
(c) Flower (d) Inflorescence

496. The drug 'Belladona' is obtained from: **(AIIMS 2001)**
(a) *Rauwolfia* (b) *Atropa*
(c) *Capsicum* (d) *Solanum*

497. Porous wood contains mainly: **(AIIMS 2001)**
(a) Fibres (b) Vessels
(c) Tracheids (d) Solid secretions

498. Jute is obtained from : **(MPPMT 2001)**
(a) Primary phloem (b) Secondary phloem
(c) Primary xylem (d) Secondary xylem

499. What is the botanical name of sugar cane? **(MPPMT 2001)**
(a) *Saccharum munja* (b) *Saccharum spontaneum*
(c) *Saccharum berberi* (d) *Saccharum officinarum*

500. *Cicer arietinum* is known as: **(MPPMT 2001)**
(a) Gram (b) Green gram
(c) Black gram (d) Dew gram

501. Hashish and charas are obtained from female flower of: **(JIPMER 2002)**
(a) *Papaver somniferum* (b) *Cannabis sativa*
(c) *Cola nitida* (d) *Piper betle*

***502.** Which one of the following is a medicinal plant ? **(JIPMER 2002)**
(a) *Jatropha curcas* (b) *Calendula officinalis*
(c) *Tagetes patula* (d) *Sesbania aegyptica*

***503.** The 'bird of paradise' plant is: **(JIPMER 2002)**
(a) *Ravenala madagascariensis*
(b) *Strelitzia reginae*
(c) *Heliconia* sps.
(d) *Musa chinensis*

504. Mixing of which in mustard oil causes 'dropsy'? **(Raj. PMT 2001)**
(a) *Argemone mexicana* (b) *Ricinus communis*
(c) *Helianthus* (d) *Datura*

505. Lemon is sour due to the presence of: **(AFMC 2002)**
(a) Acetic acid (b) Carbonic acid
(c) Citric acid (d) Sulphuric acid

506. Which of the following are new-world crops? **(CBSE 2002)**
(a) Cashew nut, potato and para-rubber
(b) Wheat, rice and tea
(c) Maize and sugarcane
(d) All of the above

507. In India, cotton industry depends upon family: **(Haryana PMT 2001)**
(a) Compositae (b) Malvaceae
(c) Palmae (d) Solanaceae

508. Which fibre crop occupies the maximum area in India? **(MPPMT 2002)**
(a) Jute (b) Cotton
(c) Flax (d) Sisal

509. Botanical name of tea is: **(MPPMT 2002)**
(a) *Piper nigrum* (b) *Thea/Camellia sinensis*
(c) *Coffea arabica* (d) *Tectona grandis*

510. A drug from root which treats mental disorder and reduces blood pressure is obtained from: **(MPPMT 2002)**
(a) *Rauwolfia serpentina* (b) *Atropa belladona*
(c) *Colchicum luteum* (d) *Digitalis purpurea*

511. Opium is extracted from: **(CPMT 2003)**
(a) *Atropa belladona* (b) *Papaver somniferum*
(c) *Vinca rosea* (d) *Azadirachta indica*

512. Quinine is obtained from: **(CPMT 2003)**
(a) Bark of *Cinchona* (b) Root of *Cinchona*
(c) Wood of *Cinchona* (d) Leaves of *Cinchona*

513. Which one among the following is true nut? **(Kerala.PMT 2003)**
(a) Walnut (b) Groundnut
(c) Cashew nut (d) Areca nut
(e) Coconut

514. The cheapest high energy fruit crop of India is: **(BV Pune 2003)**
(a) Mango (b) Apple
(c) Guava (d) Banana

515. Which of the following plant's roots are medicinal while leaves, flowers and fruits are eaten as vegetables? **(PMET Punjab 2003)**
(a) *Aleruritis fordii* (b) *Cucurbita maxima*
(c) *Helianthus annuus* (d) *Holostemma adakodein*

516. The botanical name of cabbage is: **(AFMC 2003)**
(a) *Brassica oleracea* var. botrytis
(b) *Brassica oleracea* var. capitata
(c) *Brassica oleracea* var. gongylodes
(d) *Brassica campestris*

517. Which of the following oil is used in preparation of paints and varnishes: **(Manipal 2003)**
(a) Tung oil (b) Soybean oil
(c) Linseed oil (d) All of these

518. The substance obtained from *Rauwolfia serpentina* is: **(MGIMS Wardha 2003)**
(a) Rauwolfine (b) Serpentine
(c) Reserpine (d) Tannins

ANSWERS

1—b	2—b	3—b	4—c	5—a	6—b	7—b	8—b	9—c	10—c	11—b	12—c
13—a	14—c	15—b	16—a	17—b	18—b	19—b	20—b	21—b	22—b	23—c	24—b
25—b	26—b	27—b	28—c	29—b	30—b	31—c	32—c	33—b	34—a	35—b	36—b
37—b	38—a	39—b	40—b	41—d	42—b	43—b	44—b	45—b	46—a	47—c	48—b
49—c	50—d	51—a	52—c	53—c	54—b	55—c	56—c	57—a	58—b	59—b	60—b
61—d	62—c	63—b	64—b	65—a	66—b	67—b	68—b	69—b	70—b	71—b	72—b
73—b	74—b	75—a	76—c	77—c	78—b	79—b	80—a	81—c	82—d	83—a	84—c
85—d	86—b	87—d	88—d	89—a	90—d	91—d	92—c	93—b	94—a	95—b	96—a
97—a	98—c	99—b	100—a	101—c	102—d	103—a	104—c	105—a	106—b	107—d	108—c
109—b	110—b	111—a	112—a	113—a	114—b	115—c	116—d	117—a	118—b	119—b	120—b
121—c	122—b	123—a	124—a	125—b	126—d	127—d	128—d	129—b	130—b	131—a	132—d
133—a	134—b	135—c	136—d	137—b	138—c	139—b	140—d	141—a	142—a	143—c	144—b
145—a	146—a	147—a	148—d	149—d	150—c	151—b	152—a	153—c	154—b	155—c	156—b
157—d	158—c	159—a	160—d	161—a	162—c	163—a	164—a	165—d	166—a	167—d	168—d
169—a	170—d	171—b	172—c	173—c	174—b	175—c	176—a	177—a	178—b	179—c	180—b
181—a	182—c	183—c	184—a	185—a	186—b	187—c	188—d	189—a	190—a	191—a	192—b
193—a	194—b	195—a	196—b	197—a	198—b	199—c	200—b	201—a	202—b	203—c	204—b
205—b	206—b	207—b	208—c	209—a	210—c	211—b	212—d	213—a	214—c	215—c	216—d
217—b	218—a	219—a	220—a	221—c	222—b	223—c	224—c	225—b	226—c	227—c	228—b
229—c	230—c	231—b	232—a	233—b	234—c	235—c	236—b	237—d	238—b	239—c	240—d
241—b	242—c	243—a	244—b	245—b	246—a	247—c	248—b	249—b	250—d	251—a	252—a
253—a	254—b	255—c	256—a	257—d	258—c	259—a	260—a	261—b	262—c	263—b	264—c
265—d	266—a	267—b	268—c	269—a	270—a	271—d	272—a	273—c	274—a	275—a	276—d
277—b	278—a	279—b	280—a	281—b	282—c	283—a	284—c	285—c	286—d	287—d	288—d
289—c	290—a	291—a	292—d	293—c	294—c	295—a	296—d	297—c	298—d	299—d	300—c
301—c	302—c	303—d	304—d	305—a	306—c	307—b	308—a	309—a	310—b	311—a	312—c
313—c	314—a	315—a	316—a	317—b	318—c	319—d	320—a	321—a	322—d	323—a	324—a
325—a	326—d	327—c	328—d	329—c	330—c	331—a	332—a	333—d	334—a	335—a	336—d
337—b	338—c	339—b	340—c	341—b	342—c	343—a	344—a	345—b	346—c	347—c	348—c
349—b	350—c	351—b	352—c	353—d	354—a	355—b	356—b	357—b	358—b	359—c	360—c
361—c	362—c	363—a	364—c	365—c	366—a	367—b	368—a	369—b	370—d	371—c	372—b
373—a	374—b	375—a	376—c	377—b	378—b	379—b	380—a	381—c	382—a	383—b	384—c
385—a	386—d	387—b	388—a	389—d	390—a	391—d	392—a	393—c	394—b	395—d	396—a
397—a	398—c	399—d	400—b	401—b	402—a	403—b	404—a	405—b	406—b	407—c	408—c
409—a	410—d	411—c	412—d	413—b	414—d	415—d	416—b	417—c	418—b	419—b	420—d
421—a	422—b	423—d	424—a	425—a	426—b	427—a	428—d	429—a	430—a	431—c	432—a
433—c	434—d	435—c	436—b	437—d	438—b	439—b	440—d	441—d	442—c	443—b	444—c
445—b	446—a	447—b	448—c	449—a	450—d	451—a	452—d	453—a	454—b	455—a	456—a
457—b	458—a	459—a	460—a	461—c	462—c	463—b	464—b	465—b	466—d	467—c	468—c
469—a	470—a	471—d	472—c	473—b	474—a	475—c	476—a	477—a	478—d	479—a	480—a
481—a	482—a	483—b	484—d	485—c	486—b	487—d	488—c	489—d	490—b	491—c	492—a
493—a	494—a	495—d	496—b	497—b	498—b	499—d	500—a	501—b	502—b	503—b	504—a
505—c	506—a	507—b	508—b	509—b	510—a	511—b	512—a	513—c	514—d	515—d	516—b
517—d	518—c										

EXPLANATION OF SELECTED QUESTIONS (*)

9. Black bread is obtained from flour of European rye (*Secale cereale*).
34. Angiospermous wood is having vessels and hence porous.
50. *Triticale* is man made crop, hence neither old world nor new world.
116. Bagasse is the bye-product in cane sugar industry.
157. *Zea mays* var. *everta* is popcorn.
195. Non-alcoholic beverages like tea and coffee have alkaloid caffeine.
219. Long cotton fibres on seed epidermis are called lint fibres while small one are fuzz fibres.
289. Dried and hollowed fruits of bottle gourd (*Lagenaria siceraria*) are used for making 'beens' by Speras or snake charmers.
310. Dried stem of *Ephedra* (a gymnosperm) is source of alkaloid (drug) ephedrine, used in asthama, cold, etc.
323. Heroin is derivative of morphine, an alkaloid obtained from poppy or opium (*Papaver somniferum*).
362. Anatomically secondary xylem is called wood, present in gymnosperms as well as angiosperms.
421. Meetha Jahar or Aconite or Atis is obtained from *Aconitum*, a member of family Ranunculaceae.
467. Chattisgarh region of M.P. (now separate state) is chief rice growing region called 'Dhan Ka Katora'.
481. Lack of rhodopsin is due to vitamin A deficiency and hence vitamin A rich fruits (like papaya and mango) should be taken.
492. Ganja and Charas (products of *Cannabis*) cause distortion of perception, hence hallucinogens.
502. *Calendula officinalis* belongs to family compositae and is a medicinal plant used for curing sprains.
503. *Strelitzia reginae* (fam. Musaceae), the bird of paradise plant of South Africa is cultivated for beautiful ornithophilous (bird-pollinated) flowers.

TEST PAPER–Unit–6

1. Term systematics includes:
   (a) Identification and nomenclature of plants
   (b) Nomenclature and classification of plants
   (c) Identification, nomenclature and classification of plants
   (d) Identification, nomenclature, classification and evolutionary relationships
2. Identification and classification of plants on the basis of only morphological characters is called:
   (a) Alpha-taxonomy (b) Beta-taxonomy
   (c) Biosystematics (d) New systematics
3. Father of Indian taxonomy is:
   (a) C. Linnaeus (b) H. Santapau
   (c) R. Mishra (d) Turill
4. Taxonomic group of any rank is called:
   (a) Hierarchy (b) Authority
   (c) Taxon (d) Epithet
5. In botanical nomenclature, tautonyms are:
   (a) Always invalid (b) Sometimes invalid
   (c) Always valid (d) Sometimes valid
6. Poaceae is the new name of family:
   (a) Palmae (b) Umbelliferae
   (c) Gramineae (d) Cruciferae
7. Who was the initiator of systematic botany?
   (a) Linnaeus (b) Theophrastus
   (c) De Candolle (d) Rudbeck
8. 'Species Plantarum' of Linnaeus was published in:
   (a) 1707 (b) 1753
   (c) 1778 (d) 1729
9. Which of the following is not a natural system of classification?
   (a) A. P. de Candolle's classification
   (b) Bentham and Hooker's
   (c) A. L. de Jussieu's
   (d) Hutchinson's
10. Corymb inflorescence, tetradynamous condition of androecium and presence of false septum in ovary are the features of family:
    (a) Brassicaceae (b) Malvaceae
    (c) Solanaceae (d) Cucurbitaceae
11. Botanical name of Candytuft is :
    (a) *Iberis amara* (b) *Eruca sativa*
    (c) *Brassica napus* (d) None of these
12. *Lathyrus sativus* (Khesari), which causes lathyrism belongs to:
    (a) Papilionaceae (b) Mimosaceae
    (c) Caesalpiniaceae (d) Cucurbitaceae
13. A plant having pentangular and hollow stem, leaf-opposed branched tendrils and unisexual epigynous flowers belongs to:
    (a) Malvaceae (b) Solanaceae
    (c) Cucurbitaceae (d) Liliaceae
14. Which is the largest family of flowering plants?
    (a) Cucurbitaceae (b) Poaceae
    (c) Asteraceae (d) Solanaceae
15. Hair vitalizer 'Arnica' is obtained from a plant belonging to family:
    (a) Asteraceae (b) Cucurbitaceae
    (c) Brassicaceae (d) None of these
16. A genus of family Liliaceae, which is having reticulate venation in its leaves (not parallel) is:
    (a) *Gloriosa* (b) *Smilax*
    (c) *Yucca* (d) *Asparagus*
17. The members of which family are commonly called 'grasses'?
    (a) Ranunculaceae (b) Poaceae
    (c) Liliaceae (d) Palmae
18. Presence of lodicules, versatile anthers and feathery stigmas are characteristic features of:
    (a) Gramineae (b) Malvaceae
    (c) Liliaceae (d) None of these
19. Tubular or flask-shaped zone of the floral-axis which bears floral leaves on its margins is called:
    (a) Hypanthodium (b) Hypanthium
    (c) Calyculus (d) Lodicule
20. In a floral diagram, the side towards mother axis is:
    (a) Anterior side of flower
    (b) Posterior side of flower
    (c) Sometimes anterior, sometimes posterior
    (d) Lateral side
21. The first cereal to be domesticated is:
    (a) Rice (b) Wheat
    (c) Barley (d) Maize
22. The flour of which of the following serves an excellent food for diabetics?
    (a) Buck wheat (b) Chick pea
    (c) Red gram (d) Soybean
23. *Gossypium barbadense* is a gift from:
    (a) Old world to new world (b) New world to old world
    (c) Both (a) and (b) (d) None of these
24. The fibres used for making fishing nets are:
    (a) Jute (b) Flax
    (c) Sunhemp (d) Hemp
25. A fibre of monocot fruit origin, which is highly resistant to water is:
    (a) Coir (b) Flax
    (c) Abaca (d) None of these
26. Source of jaggary is:
    (a) Sugar cane (b) Beet root
    (c) Date palm (d) Toddy palm
27. Colza oil is obtained from:
    (a) *Linum usitatissimum* (b) *Brassica campestris*
    (c) *Helianthus annuus* (d) *Sesamum indicum*

28. Tea, rice and mango are:
(a) Old world crops (b) New world crops
(c) Both (a) and (b) (d) None of these

29. Which of the following is the source of both fibre as well as biofertilizer?
(a) *Corchorus olitorius*
(b) *Crotolaria juncea*
(c) *Trifolium alexandrianum*
(d) All of these

30. Rotenones with insecticidal properties are obtained from:
(a) Roots of *Derris*
(b) Roots of *Lonchocarpus*
(c) Roots of *Melia azadirachta*
(d) Both (a) and (b)

31. The plant of maximum use to mankind is:
(a) Cotton (b) Coconut
(c) Rice (d) Pea

32. Which is not a feature of family Solanaceae?
(a) Epipetalous stamens (b) Swollen placenta
(c) Pentamerous flowers (d) Inferior ovary

33. Strychnine alkaloid stimulating nervous system is obtained from which part of *Strychnos* plant?
(a) Roots (b) Stem
(c) Seeds (d) Leaves

34. Adulteration of mustard seeds is done with seeds of:
(a) *Sterculia* (b) *Argemone mexicana*
(c) *Terminalia* (d) None of these

35. Vexillary aestivation of petals, diadelphous condition of stamens and censer mechanism of dispersal of seeds are features of:
(a) Papilionaceae (b) Caesalpiniaceae
(c) Mimosaceae (d) None of these

36. An important ingredient of Trifla called Harad (Harara) is fruit of:
(a) *Terminalia chebula* (b) *T. bellirica*
(c) *T. arjuna* (d) All of these

37. Cyathium is characteristic inflorescence of:
(a) *Ocimum* (b) *Euphorbia*
(c) *Ficus* (d) All of these

38. In which of the following pairs, endosperm is edible?
(a) Date palm and coconut (b) Arecanut and coconut
(c) Peanut and coconut (d) None of these

39. Binomial system of nomenclature was given by Linnaeus in his book:
(a) Systema Naturae (b) Hortus Uplandicus
(c) Species Plantarum (d) None of these

40. Quinine is obtained from:
(a) Bark of *Cinchona* (b) Leaves of *Cinchona*
(c) Bark of *Cinnamomum* (d) None of these

41. Bhojpatra is:
(a) Leaves of *Betula* (b) Bark of *Betula*
(c) Leaves of *Musa* (d) None of these

42. The plant with leaves of much economic importance which are source of major foreign exchange earning in India, is:
(a) *Cinnamomum camphora* (b) *Piper betle*
(c) *Camellia sinensis* (d) *Coffea arabica*

43. Hashish, Charas and Marijuana are categorized as:
(a) Toxins (b) Stimulants
(c) Hallucinogens (d) None of these

44. Source of commercial cork is :
(a) Oak (b) Berch
(c) Popular (d) Peepal

45. Cardamom hills are present in:
(a) Kerala (b) W. Bengal
(c) Tamilnadu (d) Andhra Pradesh

46. Marginal placentation and unilocular condition occur in:
(a) Brassicaceae (b) Solanaceae
(c) Fabaceae (d) Asteraceae

47. Wood belonging to family Leguminosae is:
(a) Mahogany (b) Teak
(c) Sal (d) Shisham

48. Which plant is source of fibre, oil and cattle feed?
(a) *Gossypium* (b) *Corchorus*
(c) *Crotolaria* (d) *Helianthus*

49. Best cricket bats are made of:
(a) *Morus alba* (b) *Salix alba*
(c) *Dalbergia sissoo* (d) *Juglans regia*

50. The most precise function of inflorescence is:
(a) Fruit and seed dispersal (b) Fruit formation
(c) Microspores formation (d) Pollination

51. Most widely cultivated cultivar of rice is :
(a) Jaya (b) Jagannath
(c) IR-36 (d) IR-8

ANSWERS

1—d	2—a	3—b	4—c	5—a	6—c	7—b	8—b	9—d	10—a	11—a	12—a
13—c	14—c	15—a	16—b	17—b	18—a	19—b	20—a	21—c	22—d	23—b	24—b
25—a	26—c	27—b	28—a	29—b	30—d	31—b	32—d	33—c	34—b	35—a	36—a
37—b	38—b	39—c	40—a	41—b	42—c	43—c	44—a	45—a	46—c	47—d	48—a
49—b	50—b	51—c									

UNIT-6

ASSERTION AND REASON TYPE QUESTIONS

In the questions given below, two statements—an Assertion (A) and a Reason (R) are given. Give the appropriate response as:

(a) If both A and R are true and R is the correct explanation of A.
(b) If both A and R are true and R is not the correct explanation of A.
(c) If A is true but R is false.
(d) If both A and R are false.
(e) If A is false but R is true.

1. **A :** Systematics is the branch of biology that deals with classification of living organisms.
   R : The aim of classification is to group the organisms in an orderly way.
2. **A :** System of naming plants and animals is called nomenclature.
   R : Need of scientific names was felt because the same plant is having different common names in different parts of the world.
3. **A :** Binomial system of nomenclature was given by A.P. de Candolle.
   R : According to this system, each plant is given a name made of two Greek words.
4. **A :** Tautonyms are illegitimate in botanical nomenclature.
   R : Generic and specific epithets are same in tautonyms.
5. **A :** Floral characters are mainly used in classification and identification in angiosperms.
   R : Floral characters are more stable and conservative than vegetative characters.
6. **A :** Classification of Linnaeus is sometimes called sexual system of classification.
   R : Linnaeus classification is based on characters of stamens.
7. **A :** Classification of Hutchinson is more closely related to that of Bentham and Hooker.
   R : Hutchinson's classification is based upon 24 principles of phylogenetic classification.
8. **A :** The name of the family Cruciferae is based on the shape of Corolla.
   R : There are 4 petals which are arranged in the form of cross in the flower of family Cruciferae.
9. **A :** Versatile anthers are characteristic of family Gramineae.
   R : In grasses, filament is attached to the back of anther at a point so that it can swing freely.
10. **A :** Tetradynamous condition is characteristic of family Solanaceae.
    R : Presence of 6 stamens out of which 4 are long and 2 are short, is called tetradynamous condition.
11. **A :** Three sub-families of family Leguminosae can be distinguished on the basis of corolla and androecium.
    R : Monoadelphous condition of stamens is present in family Papilionaceae.
12. **A :** *Butea monosperma* is called 'flame of the forest'.
    R : Deep red flowers are present in *Butea monosperma.*
13. **A :** *Allium sativum* (Garlic) is considered to be good for heart patients.
    R : The essential oil present in garlic reduces the blood cholesterol.
14. **A :** Legumes are the most important source of food in the world.
    R : Karyopsis is the characteristic fruit of family Leguminosae.
15. **A :** Ovary is obliquely placed in family Solanaceae.
    R : Oblique position of ovary in family Solanaceae is due to turning of posterior carpel to left and anterior carpel to right.
16. **A :** Cucurbits are bitter in taste.
    R : An alkaloid cucurbitacin is present in cucurbits which make the fruits bitter in taste.
17. **A :** Pulses are rich source of proteins.
    R : The high protein content is due to presence of root nodules in legumes.
18. **A :** Soybean flour serves an excellent food for diabetics patients.
    R : There is high protein and low carbohydrate content in the seeds of soybean.
19. **A :** Coconut is commonly known as 'Kalpavariksha'.
    R : Every part of coconut is source of a useful product for mankind.
20. **A :** Angiospermous wood is non-porous.
    R : Vessels are present in wood of angiosperms.
21. **A :** Riffle butts and gun stocks are made of walnut wood.
    R : Best carving wood is of walnut.
22. **A :** Bark of *Betula* is source of Bhojpatras.
    R : Bhojpatras were used in earlier times by saints to write.

23. **A :** Most durable wood of India is teak wood.
R : A resinous fluid is present in teakwood which protects it from action of water.

24. **A :** *Ficus elastica* is the most important source of rubber in the world.
R : This plant is native of Brazil.

25. **A :** Flax fibres are used for making fishing nets.
R : These fibres are moisture or water resistant.

26. **A :** Potato is a gift from new world to old world.
R : Centre of origin of potato is in America.

27. **A :** Ganja and charas are obtained from *Papaver*.
R : Ganja and charas are hallucinogens.

28. **A :** Cardamom is called 'Queen of Spices'.
R : Cardamom hills are present in Karnataka.

29. **A :** Essential oils are used in manufacture of perfumes.
R : Essential oils evaporate in contact with air and have a pleasant fragrance.

30. **A :** All oils are obtained from seeds.
R : Olive oil is obtained from fruit pulp.

31. **A :** Quinine is obtained from leaves of *Cinchona*.
R : Quinine is used in cure of rabies or hydrophobia.

32. **A :** *Emblica* is the richest source of vitamin C .
R : Amla is a good astringent and blood purifier.

ANSWERS

1. (c) **2.** (b) **3.** (d) **4.** (b) **5.** (a) **6.** (a) **7.** (b) **8.** (a) **9.** (a) **10.** (c)
11. (c) **12.** (a) **13.** (a) **14.** (d) **15.** (c) **16.** (a) **17.** (a) **18.** (a) **19.** (a) **20.** (c)
21. (a) **22.** (b) **23.** (a) **24.** (d) **25.** (a) **26.** (a) **27.** (c) **28.** (c) **29.** (a) **30.** (c)
31. (d) **32.** (b)

UNIT-7

- Plant Physiology (I)
- Plant Physiology (II)
- Plant Physiology (III)
- Plant Physiology (IV)
- Plant Physiology (V)
- Test Paper—Unit-7
- Assertion—Reason Type Questions (Unit 7)

Plant Physiology

Assertion – Reason type Questions one

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21

Plant Physiology (I)

GENERAL CONCEPTS, WATER ABSORPTION, ASCENT OF SAP

- General introduction
- Famous Indian physiologists
- Diffusion: Diffusion pressure
- Osmosis: Osmotic pressure, exosmosis and plasmolysis, endosmosis and deplasmolysis
- Turgor pressure
- Wall pressure
- Diffusion pressure deficit (D.P.D.)
- Relationship between diffusion pressure deficit, osmotic pressure and turgor (wall) pressure
- Water potential
- Imbibition
- Absorption of water: Active and passive water absorption, factors affecting water absorption
- Ascent of sap

PLANT PHYSIOLOGY

(*Physis* means nature of life + *Logos* means study).

So the branch which deals **with life activities of plants** is plant physiology. Or

The branch dealing with functional aspects of plants is called plant physiology.

- **Stephen Hales** is known as **Father of plant physiology.**

Plant physiology can be divided into 3 parts:

1. Physical aspects or soil, water, plant relations

e.g., water absorption, ascent of sap, transpiration, mineral absorption, mineral nutrition, translocation of organic solutes or organic food, etc.

2. Metabolism

It is of 2 types:

(a) **Anabolism :** (*i.e.*, Constructive or synthetic processes).

When simple substances unite together to form a complex substance, *e.g.*, photosynthesis, lipid synthesis, protein synthesis, etc.

(b) **Catabolism :** (*i.e.*, Catabolic processes or destructive processes).

When complex substance breaks down into a simple substances, *e.g.*, respiration, lipid breakdown, protein breakdown, etc.

3. Growth and development

Growth is final end product of successful metabolism. Further growth is quantitative change. On the other hand, Development is growth accompanied with differentiation, *i.e.*, both quantitative + qualitative change.

e.g., concept of growth, growth hormones, physiology of flowering, plant movements, etc.

FAMOUS INDIAN PHYSIOLOGISTS

Sir J.C. Bose, Prof. Asana, Prof. Parija, S.P. Sen, K.K. Nanda, M.M. Lalorya, Prof. G.S. Sirohi (First Indian to reach Antarctica), **Prof. H.Y. Mohan Ram,** etc.

DIFFUSION

Literary meaning of diffusion is **to flow out or to diffuse or to disperse or to extend in all directions.**

- Diffusion may be defined as, **"movement of particles of a matter due to their own kinetic energy".**
- Diffusion is always from region of higher concentration of particles of a matter to region of lower concentration.
- Diffusion of particles of one substance is independent of diffusion of particles of another substance.

i.e., diffusion of each substance is according to its own concentration gradient.

Factors affecting diffusion

(i) **Temperature :** $D \propto T$, because temperature increases kinetic energy of particles.

(ii) **Density :** Hydrogen diffuses 4 times faster than O_2 according to **Grahm's law of diffusion,** *i.e.*,

$$\frac{r_H}{r_O} = \sqrt{\frac{d_O}{d_H}} = \sqrt{\frac{16}{1}} = \frac{4}{1}$$

i.e., rate of diffusion of a substance is inversely proportional to square root of their densities.

(iii) **Concentration gradient :** More is the concentration gradient (difference in concentration on two sides), more will be the rate of diffusion.

(iv) **Concentration of medium through which diffusion occurs :** More dense is the medium, lesser will be the rate of diffusion.

Diffusion pressure

It is hypothetical term which describes the potential ability of a gas, liquid or solid to diffuse from its higher concentration to lower concentration.

OSMOSIS

Before going into details of osmosis, we should know different types of membranes:

(i) Permeable membrane,
(ii) Impermeable membrane,
(iii) Semipermeable membrane and
(iv) Selectively or differentially permeable membrane.

(i) **Permeable :** Which allow all solutes and solvents to pass through them are called permeable membranes, *e.g.*, **cellulosic cell walls and lignified cell walls.**

(ii) **Impermeable :** Which do not allow any solute or solvent through them are called impermeable membranes, *e.g.*, **cutinized cell wall and suberized cell walls.**

(iii) **Semipermeable :** Which allow all solvents but no solute to pass through them are called semipermeable membranes, *e.g.*, **collodion, parchment membrane, copper ferrocyanide membrane.**

(iv) **Selectively permeable :** Which allow all solvents and few selected solutes to pass through them are called selectively or differentially permeable membranes, *e.g.*, **all biological membranes, plasma membrane, tonoplast, and all membranes surrounding different cell organelles.**

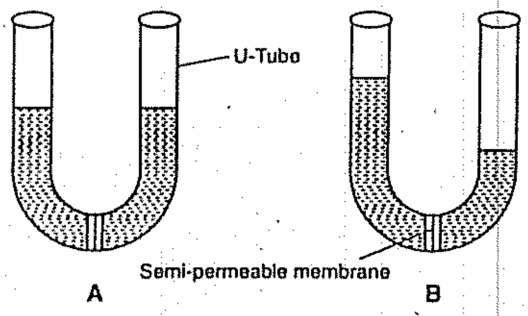


Fig. 21.1. Demonstration of Osmosis

Osmosis is a special type of diffusion or diffusion through semipermeable membrane is known as osmosis or it is a process, whereby, when a solution is separated from its weaker solution by means of a semipermeable membrane, then weaker solution passes into stronger solution so as to equalize concentration on both sides.

- Keeping in view that membrane is semipermeable, it allows only solvent molecules, so we can say that solvent moves from its higher conc. to lower conc.
- Best way of defining osmosis is on the basis of free energy levels of solvent molecules, which is the capacity of doing work. According to this concept, solvent moves from its higher free energy level to lower free energy level (as solute molecules occupy intramolecular space of solvent molecules and hence concentration of the solvent, *i.e.*, no. of molecules per unit volume is same in concentrated as well as weaker solution).
- Discovery of osmosis was made by **Pfeffer.**

Osmotic pressure (O.P.)

It is the pressure in atmosphere, which is required in opposite direction, so as to stop entry of water (solvent) molecules, when a semipermeable membrane separates concentrated solution from weaker solution.

Signification of osmosis in plants

1. Osmosis is responsible for absorption of water by roots.
2. Osmosis is responsible for turgidity of plant organs.
3. Osmosis is responsible for cell to cell movement of water.
4. It is responsible for opening and closing of stomata.
5. It is responsible for resistance of plant to drought, frost, etc.

Isotonic solution : When concentration of outer solution (in which cell is placed) is equal to concentration of cell sap, it is called isotonic solution.

Hypotonic solution : When concentration of outer solution (in which cell is placed) is lower than concentration of cell sap, it is called hypotonic solution.

Hypertonic solution : When concentration of outer solution (in which cell is placed) is higher than concentration of cell sap, it is called hypertonic solution.

Exosmosis and plasmolysis

When a cell is placed in hypertonic solution then exosmosis occurs. Due to exosmosis, the protoplasm shrinks and leaves the cell wall and thus cell becomes flaccid, which is called plasmolysed cell and this phenomenon is called plasmolysis. Thus exosmosis leads to plasmolysis.

- **In a plasmolysed cell (flaccid cell), the space between cell wall and cell membrane is filled up by outer solution.**

Endosmosis and deplasmolysis

If the plasmolysed cell (flaccid cell) is placed in hypotonic solution then endosmosis occurs, which makes the cell again turgid and this is known as deplasmolysis.

TURGOR PRESSURE (T.P.)

The pressure that develops in a cell due to osmotic diffusion of water inside it, is called T.P.

WALL PRESSURE (W.P.)

As cell wall is rigid, so it will exert equal and opposite pressure to that of T.P., which is called wall pressure (W.P.).

So, T.P. = W.P.

DIFFUSION PRESSURE DEFICIT (D.P.D.)

This term was given by Meyer.

Every liquid is having a definite diffusion pressure and **diffusion pressure of pure solvent is always more than diffusion pressure of its solution.**

e.g., if sugar solution is made in water, then D.P. of solution is lower than water (solvent).

- The amount by which D.P. of solution is lower than that of its pure solvent, is called **diffusion pressure deficit (D.P.D.).**
- In case of D.P.D., the solution will try to wipe off this difference in D.P. by sucking more water (solvent) molecules and hence **D.P.D. is the measure or index of sucking power and hence it is also called suction pressure (S.P.).**

So, **D.P.D. = S.P.** inside

(Term suction pressure was given by **Renner**).

RELATIONSHIP BETWEEN D.P.D. (S.P.), O.P. AND T.P. (W.P.)

D.P.D. (S.P.) = O.P. − T.P. (W.P.)

- Initially (or in a flaccid cell), T.P. = 0

So, D.P.D. (S.P.) = O.P.

Therefore, cell absorbs or sucks water with a force equal to O.P.

- In a fully turgid cell, D.P.D. = 0

As, T.P. = O.P.

i.e., cell has no further capacity to absorb any water.

Problem : *A and B are the two adjacent cells in which osmotic diffusion of water can occur. Cell A has O.P. = 16 atmosphere and T.P. = 8 atm. and cell B has O.P. = 12 atm., T.P. = 2 atm. What is the direction of movement of water?*

Solution : D.P.D. (S.P.) of cell A = O.P. − T.P.
= 16 − 8 = 8 atm.

D.P.D. (S.P.) of cell B = 12 − 2 = 10 atm.

∴ Movement of water is from cell A to cell B, *i.e.*, direction of movement of water is from lower D.P.D. (S.P.) to higher D.P.D. (S.P.).

WATER POTENTIAL

According to principles of thermodynamics, every component of system is having definite amount of **free energy,** which is measure of potential work which the system can do.

- The best way of explanation of osmotic movement of water is on the basis of free energy, *i.e.*, from higher free energy level to lower free energy level.
- **Free energy per mole of water molecule is called water potential.**
- Water potential is represented by Greek letter 'ψ'.
- Water potential (ψ) of protoplasm is equal but opposite in sign to D.P.D. (S.P.).
- Water potential (ψ) of pure water is zero and addition of solute in it, decreases its ψ (*i.e.*, negative value).

Here, $\psi = \psi_s + \psi_p$

where, ψ → Water potential

ψ_s → Solute potential or osmotic potential

ψ_p → Pressure potential

further,

ψ_s = O.P. but having − ve value and ψ_p = W.P. (T.P.) and always having + ve sign.

○ At normal temperature and pressure, one molar solution (1 M) has water potential (ψ) − 23 bars.

Problem : *Suppose there are two cells A and B, cell A has O. potential = − 16 bars, pressure potential = 8 bars and cell B has O. potential = − 12 bars and pressure potential = 2 bars.*

What is the direction of movement of water?

Solution :

ψ of cell A = $\psi_s + \psi_p$ = − 16 + 8 = − 8 bars

ψ of cell B = − 12 + 2 = − 10 bars

As movement of water is from higher water potential (lower D.P.D.) to lower water potential (higher D.P.D.), hence the movement of water is from **cell A** to **cell B.**

IMBIBITION

There is another process in plants for uptake of water. A dry wooden piece when soaked in water shows considerable swelling and sometimes leads to considerable increase in volume, which is due to imbibition. *e.g.*, wooden doors in rainy season swell due to imbibition phenomenon.

○ Due to imbibition, sometimes a considerable pressure is developed which is known as **imbibitional pressure,** *e.g.*, a wooden piece driven into a hole in the rock on imbibition swells so much that the pressure developed by it breaks the rock.

Conditions necessary for imbibition

1. A water potential gradient should occur between imbibant (wooden piece) and liquid imbibed (*e.g.*, H_2O). Wooden piece is having larger negative water potential and water is having water potential equal to zero, so there is difference in water potential (*i.e.*, water potential gradient).

2. There should be some forces of attraction between imbibant and imbibed liquid or affinity between imbibant and imbibed liquid is necessary for imbibition to occur.

e.g., if wooden piece soaked in ether, no swelling or no imbibition, but wooden piece in water shows swelling due to imbibition. Similarly rubber soaked in H_2O shows no imbibition and rubber in ether shows imbibition.

- First step in imbibition is **adsorption**, *i.e.*, attachment of liquid on the surface.

Adsorption is the property of colloids and hence the materials which have high proportion of colloids, are good imbibants.

It is for this reason, the wood (plant material) is good imbibant, because it contains proteins, cellulose and starch as colloidal substances.

Characteristics of imbibition

1. Volume is increased,
2. Heat is produced and
3. Pressure is developed.

Significance of imbibition

1. It is the dominant and first step of water absorption.
2. Imbibition is the first step in germination of seeds, *i.e.*, first imbibition occurs by seed coat and then by embryo and other parts.

ABSORPTION OF WATER

Water is absorbed from soil by root system and specially by younger parts (*i.e.*, root tips).

- Maximum absorption of water occurs by **root-hair zone**, although some amount of water is absorbed by zone of elongation and no absorption by root cap and meristematic zone.
- Root hair is a tubular prolongation from peripheral wall of epiblema or rhizodermis or piliferous layer. **Root hair is 1 mm to 1 cm in length and 10 µ in diameter.**
- Root hairs are more developed in herbs as compared to shrubs and trees.
- Root hairs are more developed in angiosperms than gymnosperms. In some conifers root hairs are either totally absent or poorly developed and there occurs association of fungal hyphae with roots (*i.e.*, **mycorrhiza**).
- Root hairs in some cases are several hundred per square mm of root surface but in most of the cases number is comparatively less. Root hairs increase the absorptive surface area of roots.

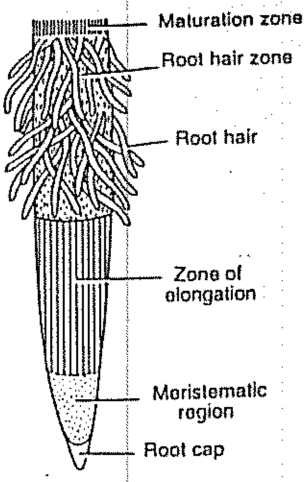


Fig. 21.2. Root tip showing root hair zone

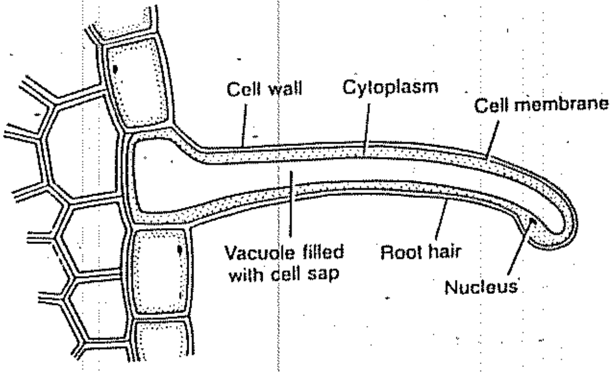


Fig. 21.3. Structure of a single root hair

- Root hair is having **permeable cell wall, with outer layer of pectic substances** (for attachment of soil particles) **and inner layer of cellulose. Inner to cell wall is selectively permeable cell membrane** and layer of protoplasm with single nucleus near the tip. In the centre is vacuole with cell sap, having osmotic pressure **3–5 atmospheres** (O.P. of outer soil water is generally less than 1 atmosphere).

Mechanism of water absorption

There are two independent mechanisms of water absorption in plants:

1. Active water absorption
2. Passive water absorption

1. Active water absorption

Here water is absorbed by the activity of root itself or roots play active role or water is absorbed **'by the roots'. It is common in plants with low transpiration rate.**

(a) Osmotic theory of active water absorption : First step of water absorption is imbibition by cell wall of root hair and as cell wall is permeable, water as well as solutes enter through it and reach at surface of cell membrane. Now outer soil water is separated from cell sap of root hair by means of a selectively permeable membrane (cell membrane + cytoplasm).

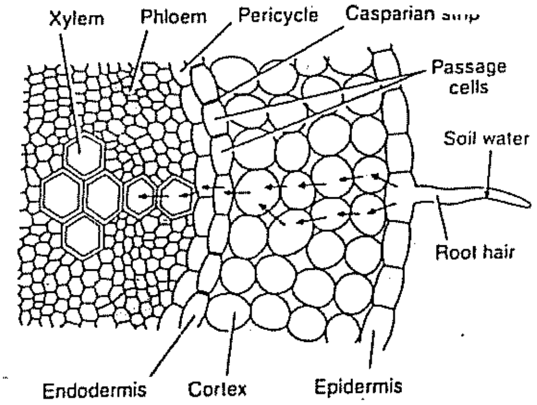


Fig. 21.4. Diagram showing lateral transfer of water from root hair to xylem

- Due to high O.P. and low T.P., the D.P.D. or S.P. of root hair is increased and thus water is absorbed by endosmosis. After absorption of water by root hair, its T.P. is increased and thus D.P.D. or S.P. is decreased. Water from root hair moves to inner cells of root along conc. gradient and finally reaches into the xylem. As xylem is continuous from roots to leaves, so this goes upwards for consumption.

(b) Non-osmotic theory of active water absorption : Generally it has been seen that absorption of water still occurs when conc. of outer soil water is more than root hair cell sap. Under such conditions, exosmosis should occur, but it has been seen that **water is still absorbed against conc. gradient.** Osmotic theory does not explain this but is explained by non-osmotic mechanism **utilizing respiratory energy. Thus absorption of water against conc. gradient utilizing respiratory energy is non-osmotic theory of active water absorption.** It is verified by evidences that the factors (low temp., poor oxygen, sodium azide, iodoacetic acid and KCN) which decrease rate of respiration, also decrease water absorption. On the other hand **auxins** increase rate of respiration as well as water absorption.

2. Passive water absorption

Here **roots play passive role** in water absorption, *i.e.*, forces responsible for absorption of water are not generated in roots, but in upper parts of the plant, *i.e.*, **'transpiration pull'.**

Or

'Absorption through roots' is passive water absorption.

- o It is observed in plants with high transpiration and passive water absorption is responsible for **98%** of total water absorption in plants.

According to this theory loss of water from mesophyll cells of leaves in transpiration decreases their T.P. and hence increases their D.P.D. or S.P. As a result of their increased D.P.D. or S.P., they absorb water from adjacent xylem vessels of leaves (reservoir of water). As a result of which, a pull or tension is created in xylem vessel. Xylem of the leaves is in continuation with xylem of stem and roots and hence this pull is transmitted downwards. The pull or tension is removed only when water is absorbed through root hair and this is passive water absorption. Thus transpiration pull is responsible for passive water absorption.

Factor's affecting water absorption

1. **Availability of water :** Capillary water is the only water which can be absorbed by the roots of plant. In general, plants absorb water between field capacity and permanent wilting percentage. No water is absorbed below permanent wilting percentage or wilting coefficient.

2. **Temperature :** Optimum temperature for water absorption is 20–35°C.

No water is absorbed in frozen soils. Rate of water absorption decreases below 20°C because of increased viscosity of H_2O, decreased permeability of membranes, poor root growth and low metabolic rate.

3. **Concentration of soil water :** Water is generally absorbed when conc. of root hair cell sap is more than outer soil water. If conc. of soil water is high due to dissolved salts (saline soil), there are chances of exosmosis. Such soils are called **physiologically dry soils.**

- o **(It is a common practice to irrigate the soil after addition of fertilizers so as to decrease soil water concentration).**

4. **Aeration :** In poorly aerated soil, rate of water absorption is low. In poorly aerated soil, lack of O_2 and increase in CO_2 occurs. Due to these factors viscosity of water is increased and permeability of membranes is decreased and there is poor root growth. All these factors together decrease water absorption.

ASCENT OF SAP

Water is mainly absorbed by roots, which goes upwards so as to replace water loss in transpiration and to be used in photosynthesis. This upward movement of water from roots to leaves through stem against force of gravity is called **ascent of sap.**

The exact mechanism of ascent of sap is not clear but one thing is very clear that **path of ascent of sap is xylem (lumen of xylem and not the walls).**

Evidences

(i) When a cut shoot of balsam plant is immersed in solution of eosine or basic fuchsine, its flowers turn red and when T.S. of stem is cut, only xylem is stained red.

(ii) Ringing or Girdling experiment :

- Ringing experiment was first of all performed by **Hartig** (1837). In first set of experiment, when ring or girdle of bark (phloem + cortex) is removed from a dicot plant, the leaves in upper part do not wilt because water continues to rise up through central xylem. In second set of experiment, when central portion (xylem) of dicot stem is removed, leaves in upper part wilt as water is unable to rise up.

○ (Ringing experiments cannot be performed in monocots due to presence of scattered vascular bundles in stem).

- In old woody trees conduction function is performed by peripheral light coloured sap wood (and not by heart wood).

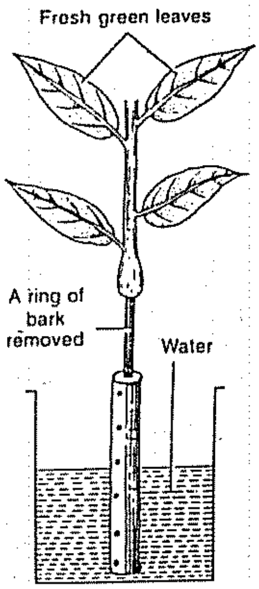


Fig. 21.5. Ringing experiment to show xylem as path of ascent of sap

Mechanism of ascent of sap

Ascent of sap is interesting and complicated problem because movement of water is against force of gravity. In small herbaceous plants, the mechanism may be simple but in tall trees like *Sequoia* and *Eucalyptus* (375 ft), the mechanism of ascent of sap is not so simple.

Different theories have been given from time to time and all of these are grouped into 3 heads:

I. Root pressure theory
II. Vital force theories
III. Physical force theories.

(I) Root pressure theory

Stem of recently fallen tree or detopped herbaceous plant shows the evidence of root pressure. Here xylem sap is seen to come out of the cut end, which is called exudation or bleeding.

- **Priestley** was the first person who reported that bleeding or exudation is due to root pressure. **Stocking** defined root pressure as, "pressure developed in tracheary elements of roots due to activity of root itself" (active process).
- Stephen Hales (1727) coined the term root pressure.
- Root pressure is developed when rate of water absorption is more than the rate of transpiration and as a result of which water is pushed up in tracheary elements of root. Some workers explained ascent of sap due to root pressure but following objections were raised:

(i) Magnitude of root pressure is maximum upto 2 atmosphere whereas about 20 atmosphere pressure is required to raise water to top of tall trees.

(ii) Root pressure is absent in most of the conifers.

(iii) Root pressure is absent in rapidly transpiring plants.

(iv) Exudation or bleeding rate is much slower than upward movement of water.

Further it was reported by **Strasburger** that even in absence of roots, water rises up.

(II) Vital force theories

The advocates of vital force theory say that ascent of sap is due to vital activities of cells of stem or living cells are **responsible for ascent of sap.**

Main supporters of vital force theory are **Westermaier** (1883, 84), **Godlewski** (1884), **Sir J.C. Bose** (1923) and **Molisch** (1928).

Westermaier (1883, 84) considered that only cells of xylem parenchyma provide the force for ascent of sap.

Godlewski (1884) gave **'clambering force theory'** or **'relay force theory'**. According to him, vital activities of cells of **xylem parenchyma** and **medullary rays** are responsible for ascent of sap. These cells have rythmic change in their O.P. when O.P. of these cells is high, they absorb water from

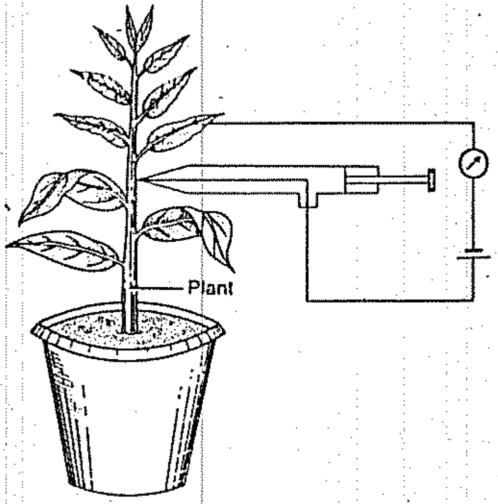


Fig. 21.6. Electric probe experiment of Sir J.C. Bose

adjoining xylem vessel and when O.P. is low, they push water into next higher vessel thus a stair case like movement occurs in plants during ascent of sap.

Janse (1887) supported this theory but Strasburger reported that if these cells are killed with high temperature or picric acid, even then water continues to rise up.

Sir J.C. Bose (1923) gave pulsatory-force theory, according to which innermost layer of cortex (just outside endodermis) is responsible for ascent of sap. J.C. Bose verified this with the help of **'electric-probe experiment'**.

When this electric probe reached in innermost layer of cortex, the vibrations in galvanometer were violent.

- One complete cycle of contraction and relaxation of innermost cortical cells (pulsatory activity) takes 14 seconds.

Molisch (1928) supported Sir J.C. Bose and said that the pulsatory activity of innermost layer of cortex can be increased by cardiac stimulating drugs.

- Dixon criticized this theory as he was unable to verify the results.

(III) Physical force theories

Supporters of these theories are of opinion that forces responsible for ascent of sap are purely **physical in nature** and even dead cells can raise water.

Main physical force theories are:

(i) Atmospheric pressure theory: Atmospheric pressure can raise water only upto 33 ft.

(ii) Imbibitional force theory: First given by Unger (1868) and later supported by Sachs (1878). According to this theory, ascent of sap is due to imbibition by thick-walls of xylem vessels, but ringing experiments have already proved that ascent of sap is through lumen of xylem and not through walls.

(iii) Capillary force theory: Given by Boehm. According to this theory, xylem vessels act as minute capillaries and water rises in these capillaries due to capillary action or surface tension but open meniscus is required for surface tension to occur and in plants, no free meniscus is there.

(iv) Transpiration pull theory or Cohesion tension theory: Given by **Dixon** and **Jolly** (1894) and later supported by **Curtis** and **Clark** (1951) and **Kramer** and **Kozlowski** (1961).

- It is the **most accepted** theory of ascent of sap.

Main points of this theory are:

(a) Water forms a continuous column from root to leaf through xylem ducts.

(b) Loss of water from mesophyll cells of leaves due to transpiration decreases their T.P. and hence increases their D.P.D. (as D.P.D. (S.P.) = O.P. – T.P.). As a result of increased S.P., they absorb or suck water from adjacent xylem vessels of leaves and thus xylem sap is under pull or tension.

This pull or tension is transmitted downward and is relieved when water is absorbed through roots.

(c) The column of xylem resists breaking due to forces of cohesion (between water-water) and **adhesion** (between wall and water). Thus water is pulled from roots as a result of transpiration pull.

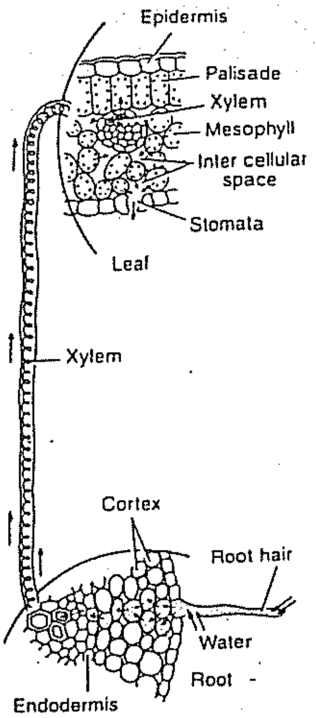


Fig. 21.7. Representation of ascent of sap due to transpiration pull theory

Evidences in favour of this theory are:

(a) Osmotic pressure of mesophyll cells is found to be **20 atmosphere**, which is sufficient to suck water from xylem vessels.

(b) The tensile strength of xylem sap is found to be **25 to 300 atmosphere**, which is sufficient to resist breaking of the column of water.

(c) Dendrographic studies also support this theory because in plants with high transpiration, diameter of xylem vessels is found to be less as compared to plants with low transpiration.

(d) The theory also gets support from **porous pot-experiment.**

So this is **purely physical process** and does not require living cells.

Objections against this theory

(i) There are enough chances of air bubbles in xylem ducts, which may break continuity of the column.

(ii) This theory considers tracheids to be more efficient than vessels for ascent of sap but why angiosperms have chosen vessels for this purpose?

Although there is no fully accepted theory of ascent of sap, but uptill now **transpiration pull theory** by **Dixon and Jolly** is the best explanation.

MULTIPLE CHOICE QUESTIONS

1. Which branch of botany deals with functional aspects of plants?
(a) Morphology (b) Physiology
(c) Ecology (d) Embryology

2. Who is called father of plant physiology?
(a) Calvin (b) J.C. Bose
(c) Stephen Hales (d) Van Helmont

3. Which of the following is not a plant physiologist?
(a) Parija (b) Asana
(c) M.M. Laloryа (d) P.N. Mehra

4. Who is the first Indian to reach Antarctica?
(a) K.K. Nanda (b) S.P. Sen
(c) G.S. Sirohi (d) Parija

5. In terms of permeability, the cell wall and plasmalemma are:
(a) Permeable and differentially permeable
(b) Both semipermeable
(c) Semipermeable and differentially permeable
(d) Both differentially permeable

6. If the cell is placed in hypertonic solution, what will happen?
(a) Endosmosis (b) Exosmosis
(c) Deplasmolysis (d) No change

7. D.P.D. means:
(a) Diffusion pressure demand
(b) Daily phosphorus demand
(c) Daily photoperiodic duration
(d) Diffusion pressure deficit

*8. A cell is placed in 0.5 M solution of sugar and no change in volume of cell is there, what is the conc. of cell sap?
(a) 4 M (b) 5 M
(c) 0.5 M (d) 50 M

9. Diffusion pressure of pure solvent is:
(a) Always more than its solution
(b) Sometimes more than its solution
(c) Less than its solution
(d) Equal to its solution

10. Suction pressure of cell is:
(a) Equal to wall pressure (b) Equal to turgor pressure
(c) Equal to D.P.D. (d) Osmotic pressure

11. D.P.D.:
(a) O.P. × T.P. (b) O.P. + T.P.
(c) O.P. – W.P. (d) T.P. – W.P.

12. What will be zero in a fully turgid cell?
[BCECE (P.T. Exam.) 2001; AFMC 2002]
(a) T.P. (b) W.P.
(c) S.P. (d) O.P.

13. Plasma membrane controls:
(a) Passage of H_2O
(b) Passage of water and some solutes into and out of the cell
(c) Passage of water and solutes into the cell
(d) Passage of cell contents out of the cell

14. In a flaccid cell, what will be zero?
(a) S.P. (b) O.P.
(c) D.P. (d) W.P.

15. In a flaccid cell:
(a) S.P. = O. (b) S.P. = O.P.
(c) S.P. > O.P. (d) S.P. < O.P.

16. Water potential can be calculated as:
(a) π + W.P. (b) ψ + W.P.
(c) Osmotic potential + T.P. (d) π + T.P.

17. Which of the following is against conc. gradient?
(a) Transpiration (b) Translocation
(c) Diffusion (d) Osmosis

18. Seeds when placed in water swell because of:
(a) Osmosis (b) Root pressure
(c) Imbibition (d) Diffusion

19. Water potential of pure water and its solution are:
(a) 0 and 1 (b) 0 and 0
(c) 0 and more than 0 (d) 0 and less than 0

20. Cell A with O.P. = 6 and W.P. = 5 is surrounded by the cells with O.P. = 3 and T.P. = 2, what will be direction of water movement?
(a) From A to other cells (b) From other cells to A
(c) No movement (d) Water will move up

*21. When a cell is kept in 0.5 M solution of sucrose, its volume does not change. If the same cell is placed in 0.5 M solution of NaCl, the volume of cell will: (Orissa JEE 2002)
(a) Increase
(b) Decrease
(c) Cell will be plasmolysed
(d) No change

22. To demonstrate plasmolysis in the laboratory, which of the plant is used?
(a) *Impatiens balsamea* (b) *Tropaeolum*
(c) *Tradescantia* (d) All of these

23. O.P. of the cell can be measured by:
(a) Manometric method (b) Photometric method
(c) Plasmolytic method (d) Colorimetric method

24. What determines the diffusion of water from one cell to other cell?
(a) O.P. (b) W.P.
(c) D.P.D. (d) T.P.

25. Cell A has osmotic pot. = – 15 bars and pressure pot. = 8 bars and cell B has osmotic pot. = – 12 bars and wall pressure 2 bars, what is direction of flow?
(a) A $\rightarrow$ B (b) B $\rightarrow$ A
(c) No movement (d) A $\leftrightarrow$ B

26. Why plants die when over fertilized? (Kerala PMT 2002)
(a) As a result of dehydration
(b) Due to damage of walls of root hairs
(c) Due to blockage of nitrogenous ions
(d) Due to upsets in soil environment by poisonous soil bacteria

27. The form and structure of cell is maintained due to:
(a) Atmospheric pressure (b) Plasmolysis
(c) Turgidity (d) W.P.

28. The root hairs arise from:
(a) Pericycle (b) Epiblema
(c) Endodermis (d) Cortex

29. The root hairs zone in roots is:
(a) Permanent (b) Temporary
(c) Both (a) and (b) (d) None of these

30. Root hairs are more developed in:
(a) Herbs (b) Shrubs
(c) Trees (d) Equally developed

31. The diameter of root hairs is:
(a) 1 μ (b) 1 cm
(c) 10 μ (d) None of these

32. Active water absorption accounts for what % of water absorption?
(a) 5% (b) 2%
(c) 90% (d) 98%

33. The water absorption 'through' the roots is called:
(a) Active (b) Passive
(c) Both (a) and (b) (d) None of these

34. Water will be absorbed by root hairs when:
(a) Concentration of salts in soil is high
(b) Concentration of solutes in the cell sap is high
(c) Plant is rapidly transpiring
(d) They are separated from soil by semipermeable membrane

35. Water from the soil enters into the root hairs on account of:
(a) T.P. (b) S.P.
(c) Barometric pressure (d) Osmotic pressure

36. Sodium azide and iodoacetic acid:
(a) Increase water absorption
(b) Decrease water absorption
(c) No change
(d) Not known

37. Optimum temperature for water absorption is:
(a) 10–20°C (b) 20–35°C
(c) 15–25°C (d) None of these

38. The soil is physiologically dry when:
(a) It has no hygroscopic water
(b) Conc. of soil solution is higher than cell
(c) Soil temp. is 4°C
(d) Excess of CO_2 in soil

39. Which of the following does not involve osmosis?
(a) Water passing from root hair to adjacent cells
(b) Water passing up a xylem element to another element above it
(c) Water entering mesophyll cell from xylem elements
(d) Water from soil in the root hair

40. The absorbed water can rise to highest point by:
(a) Root pressure (b) Imbibition force
(c) Force of capillary (d) Transpiration pull

41. Path of upward translocation of water is: **(MPPMT 1999)**
(a) Phloem (b) Xylem walls
(c) Xylem lumen (d) Cortex

42. Girdling experiment was first performed by:
(a) Kramer (b) J.C. Bose
(c) Strasburger (d) Hartig

43. The pressure developed in tracheary elements of xylem due to metabolic activity of roots is called:
(a) O.P. (b) T.P.
(c) Root pressure (d) Atmospheric pressure

*44. Root pressure is measured by: **(Raj. PMT 2001)**
(a) Potometer (b) Barometer
(c) Manometer (d) Auxanometer

45. Root pressure is maximum when: **(JIPMER 2002)**
(a) Transpiration is high and absorption is low
(b) Transpiration is very low and absorption is high
(c) Both are very high
(d) Both are very low

46. Sir J.C. Bose is supporter of .... theory of ascent of sap.
(a) Root pressure theory (b) Physical force theory
(c) Vital force theory (d) None of these

47. 'Clambering force theory' of ascent of sap was put forward by:
(a) J.C. Bose (b) Sachs
(c) Godlewski (d) Molisch

48. 'Exudation' is due to:
(a) O.P. (b) Root pressure
(c) Diffusion pressure (d) Transpiration pull

49. Root pressure is absent in:
(a) Rapidly transpiring plants
(b) Conifers
(c) Plant growing in cold soils
(d) All of the above

50. Term 'Root pressure' was first given by:
(a) Priestley (b) Stephen Hales
(c) Stocking (d) Godlewski

51. The role of innermost layer of cortex in ascent of sap was proposed by:
(a) Godlewski (b) Molisch
(c) J.C. Bose (d) None of these

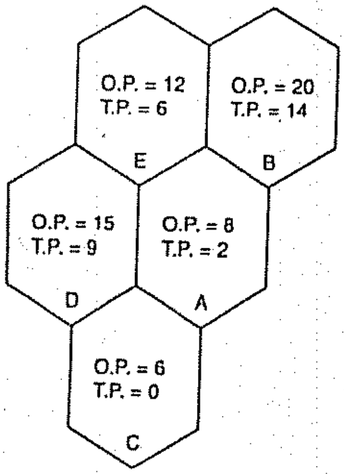
52. Ascent of sap in absence of roots was observed by:
(a) J.C. Bose (b) Priestley
(c) Strasburger (d) None of these

53. Imbibitional theory of ascent of sap was given by:
(a) Sachs (b) Unger
(c) Boehm (d) Molisch

54. Electric probe experiment was performed by:
(a) Godlewski (b) J.C. Bose
(c) Dixon and Jolly (d) Barton Wright

55. Cohesion tension theory of ascent of sap was given by: **[BCECE (P.T.Exam.) 2001]**
(a) Curtis (b) Dixon and Jolly
(c) Kramer and Kozlowski (d) None of these

56. The above theory gets support from:
    - (a) Dendrographic measurements
    - (b) Porous pot experiment
    - (c) High tensile strength of xylem sap
    - (d) All of the above
57. Cell sap is:
    - (a) Living content of vacuole which controls osmotic relation
    - (b) Living content of cell which controls osmotic relation
    - (c) Non-living content of cell
    - (d) Non-living content of vacuole
58. Wilting occurs when: **(CPMT 2002)**
    - (a) Phloem is blocked
    - (b) Xylem is blocked
    - (c) Both xylem and phloem are blocked
    - (d) A few roots are removed
59. 'Pulsatory force theory' of ascent of sap was given by:
    - (a) Molisch
    - (b) J.C. Bose
    - (c) Boehm
    - (d) Godlewski
60. The most widely accepted theory of ascent of sap is: **(BHU 2001)**
    - (a) Capillary force theory
    - (b) Atmospheric pressure theory
    - (c) Pulsating action of living cells
    - (d) Transpiration pull and cohesion tension theory
61. Swelling of wooden doors during rainy season is due to: **(AIIMS 2001)**
    - (a) Endosmosis
    - (b) Deplasmolysis
    - (c) Capillarity
    - (d) Imbibition
62. Many transplanted plants do not survive due to: **(CET Karnataka 2000)**
    - (a) They do not like new soil
    - (b) They do not get required mineral salt
    - (c) Most of the root hairs are lost during transplantation
    - (d) Leaves get damaged
63. In the following diagram, if the T.P. of cell B increases to 18, what would be the changes with regard to water movement?



    - (a) A, C, D and E absorb water from B
    - (b) Water diffuses into B
    - (c) B actively absorbs water from neighbouring cells
    - (d) No movement
64. The initial stage of water absorption by root cells is:
    - (a) Adsorption
    - (b) Desorption
    - (c) Osmosis
    - (d) Imbibition
65. In osmosis, water moves from:
    - (a) Higher conc. to lower conc. of solvent
    - (b) Lower conc. to higher conc. of solute
    - (c) Higher water potential to lower water potential
    - (d) All of the above
66. The terms D.P. and D.P.D. were given by:
    - (a) Kramer
    - (b) Renner
    - (c) Meyer
    - (d) None of these
67. Term S.P. (suction pressure) was given by:
    - (a) Kramer
    - (b) Renner
    - (c) Meyer
    - (d) Anderson
68. A solution of 1 M sucrose is subjected to an osmometer. It develops a pressure of 27 bars. Which of the following is correct?
    - (a) Osmotic potential of solution is –27 bars
    - (b) Osmotic pressure is –27 bars
    - (c) Pressure potential is –27 bars
    - (d) Wall pressure is –27 bars
69. When a plant wilts, sequence of events will be as: **(Kerala PMT 2002)**
    - (a) Exosmosis, deplasmolysis, plasmolysis, temporary and permanent wilting
    - (b) Exosmosis, plasmolysis, deplasmolysis, temporary and permanent wilting
    - (c) Exosmosis, plasmolysis, temporary and permanent wilting
    - (d) None of the above
70. Pulsation theory of ascent of sap was proposed by: **(CPMT 1991; BCECE 2002)**
    - (a) Dixon and Jolly
    - (b) J.C. Bose
    - (c) Curtis and Clarke
    - (d) None of these
71. First theory for the ascent of sap was proposed by:
    - (a) Westermaier
    - (b) J.C. Bose
    - (c) Godlewski
    - (d) Stephen Hales
72. A girdled tree (upto bast) may survive for some time but it will eventually die because: **(BHU 1994)**
    - (a) Water will not move upwards
    - (b) Water will not move downwards
    - (c) Sugars and other organic materials will not move downwards
    - (d) Sugars and other organic materials will not move upwards
73. Cohesion theory for the ascent of sap was proposed by: **(AFMC 1993)**
    - (a) Bose and Jolly
    - (b) Dixon and Jolly
    - (c) Molisch
    - (d) Godlewski
74. How does the removal of a ring of bark and wood from the trunk of a tree kills it?

(a) Mineral salts cannot go up
(b) Immediate stoppage of photosynthesis
(c) Water cannot go up
(d) The exposed part dies due to heat

75. Vital force theory for the ascent of sap was proposed by: **(MDAT Bihar 1991)**
(a) Stephen Hales (b) Boehm
(c) Sachs (d) Godlewski

76. Who proposed "Relay pump theory" of the ascent of sap? **(BV Pune 2003)**
(a) Godlewski (b) Sachs
(c) J.C. Bose (d) Strasburger

77. Water rises in the stem due to:
(a) Turgor pressure
(b) Cohesion and transpiration pull
(c) Osmotic pressure
(d) None of the above

78. Which of the following contributes most to transport of water from the ground to the leaves of a tall tree?
(a) Break down of ATP
(b) Root pressure
(c) Capillary rise of water in xylem
(d) Cohesion of water and transpiration pull

79. In the ascent of sap water moves up in:
(a) Xylem (b) Phloem
(c) Cambium (d) Endodermis

80. Water in plant is transported by (ascent of sap takes place through) or (which one of the following is connected with transport of water in plants)?
(a) Phloem (b) Cambium
(c) Epidermis (d) Xylem

81. The cohesive force of water is due to:
(a) S-bonds (b) O-bonds
(c) H-bonds (d) OH-bonds

82. When stem of plant is girdled (ringed):
(a) The root dies first
(b) The shoot dies first
(c) The roots and the shoot will die at the same time
(d) Neither the root nor the shoot will die

83. The important force or factor which best explains the rise of water in tall trees is?
(a) Osmotic pressure (b) Turgor pressure
(c) Root pressure (d) Cohesion

84. Water absorbed by roots reach to the top of a tall tree by means of:
(a) Root pressure
(b) Capillary force
(c) Transpiration-pull and cohesion of water molecules
(d) Pulsation and imbibition

85. Semipermeability is the property of:
(a) Plasma membrane (b) Cell wall
(c) Golgi body (d) Endoplasmic reticulum

86. When a seed is placed in a suitable medium for germination, by which of the following first processes water enters into the seed coat?
(a) Imbibition (b) Absorption
(c) Osmosis (d) Root pressure

87. Selective permeability identifies the process of:
(a) Diffusion (b) Osmosis
(c) Plasmolysis (d) Imbibition

88. Root hairs occur in the zone of:
(a) Cell maturation (b) Cell division
(c) Cell elongation (d) None of these

89. Selective permeability is the characteristic of:
(a) Cell wall (b) Cell membrane
(c) Middle lamella (d) Cytoplasm

90. When plant cells are kept in a hypertonic salt solution they get: **(MPPMT 1994)**
(a) Lysed (b) Plasmolysed
(c) Deplasmolysed (d) Turgid

91. Grapes immersed in water would shrink if: **(Raj. PMT 1990)**
(a) Water contains salts (b) Water contains starch
(c) Water is cold (d) Water is hot

92. What determines the diffusion of water from one cell to other?
(a) Diffusion pressure deficit
(b) Hydrostatic pressure
(c) Osmotic pressure
(d) Wall pressure

93. In osmosis solvent flows from the solution of:
(a) Higher concentration to lower concentration
(b) One cell to another cell
(c) Lower concentration to higher concentration
(d) None of the above

94. If a cell is reduced in size on placing in a solution of sugar, the solution is:
(a) Hypertonic (b) Hypotonic
(c) Isotonic (d) None of these

95. Under natural conditions the osmotic pressure is: **(Raj. PMT 1990)**
(a) More than turgor pressure
(b) Less than turgor pressure
(c) Equal to turgor pressure
(d) Zero

96. Seeds swell when placed in water due to or seeds absorb water during germination by:
(a) Diffusion (b) Adsorption
(c) Imbibition (d) Osmosis

97. Which one of the following scientists used the nutrient culture solution in hydroponic cultures? **(MPPMT 1995)**
(a) Sachs (b) Webster
(c) Wallace (d) Knop

98. What should happen if a thin slice of sugar beet is placed in a concentrated solution of NaCl?
(a) It should become turgid
(b) It should neither absorb water nor loose it
(c) It should absorb water from the NaCl solution
(d) It should loose water from the cells

99. Active absorption of water from the soil by the roots is mainly affected by:
(a) Tension due to transpiration
(b) Typical tissue organization
(c) Sucking power of the roots hairs
(d) Osmotic concentration of the cell sap of the leaves

100. Water enters into root hairs mainly due to: **(CPMT 1992)**
(a) Turgor pressure (b) Atmospheric pressure
(c) Elasticity (d) Osmotic pressure

101. If cell A with O.P. = 5 and T.P. = 4 is surrounded by the cells with O.P. = 3 and T.P. = 1, what will be direction of water movement:
(a) Water will not move up
(b) Water will move up
(c) From cell A to other cells
(d) From other cells to cells A

102. Ringing (girdling) experiment cannot be performed in:
(a) Sugar cane (b) Mango
(c) Indian rubber plant (d) Tecoma

103. In a plant cell the osmotic pressure is equal to: **(MPPMT 1990)**
(a) Turgor pressure—Diffusion pressure
(b) D.P.D. + T.P.
(c) D.P.D. –T.P.
(d) Turgor pressure –D.P.D.

104. Amount of water left in soil after drainage of gravitational water is complete is known as:
(a) Field capacity (b) Storage capacity
(c) Soil water (d) Gravitational capacity

105. Cell becomes plasmolysed or raisins shrink in hypertonic solution due to:
(a) Osmosis
(b) D.P.D.
(c) More endosmosis and less exosmosis
(d) More exosmosis and less endosmosis

106. The process of selective transmission through semipermeable membrane is termed as:
(a) Diffusion (b) Imbibition
(c) Osmosis (d) Plasmolysis

107. First step in the flux of water into a plant or a root hairs cell or a seed is:
(a) Osmosis (b) Imbibition
(c) Absorption (d) Suction

108. The movement of water from one cell of the cortex to the adjacent one in roots is due to: **(CBSE 1995)**
(a) Accumulation of inorganic salts in the cells
(b) Accumulation of organic compounds in the cells
(c) Chemical potential gradient
(d) Water potential gradient

*109. Which of the arbitrary values of D.P.D., O.P. and T.P. appear correct for a turgid cell?
(a) D.P.D. 02 atm; O.P. 07 atm; T.P. 5 atm.
(b) D.P.D. 00 atm; O.P. 15 atm; T.P. 15 atm.
(c) D.P.D. 10 atm; O.P. 15 atm; T.P. 6 atm.
(d) D.P.D. 05 atm; O.P. 12 atm; T.P. 7 atm.

110. When pieces of potato tissue were placed in a solution, after some time a loss in weight was recorded, the possible reason could be:
(a) Death of tissue (b) Exit of solutes
(c) Exosmosis (d) Respiration of tissues

111. Water in plants is transported by: **(BHU 1991; AFMC 1993)**
(a) Cambium (b) Phloem
(c) Xylem (d) Epidermis

112. During absorption of water by roots the water potential of cell sap is lower than that of: **(BHU 1994)**
(a) Pure water and soil solution
(b) Neither pure water nor soil solution
(c) Pure water but higher than that of soil solution
(d) Soil solution but higher than that of pure water

113. Movement of water molecules through selective permeable membrane is known as: **(CPMT 1993)**
(a) Autolysis (b) Osmosis
(c) Diffusion (d) Plasmolysis

114. Plasmolysis occurs due to: **(Raj. PMT 1990)**
(a) Exosmosis
(b) Endosmosis
(c) Presence of solutes
(d) Semipermeability of cell membrane

115. Larger molecules (bulk flow) are taken into the cell by : **(Raj. PMT 1990)**
(a) Osmosis
(b) Pinocytosis
(c) Pinocytosis and phagocytosis
(d) Phagocytosis

116. Bacteria cannot survive in a highly salted pickle because: **(MPPMT 1990)**
(a) Salt inhibits reproduction of bacteria
(b) Enough light is unavailable for photosynthesis
(c) They become plasmolysed and death occurs
(d) Nutrients in the pickle medium cannot support life

*117. In hypertonic solution, a cell's water potential:
(a) Increases
(b) Decreases
(c) First increases and then decreases
(d) Remains unchanged

*118. An alcohol–dipped cell kept in hypertonic sucrose solution will: **(CPMT 1994, 97)**
(a) Burst (b) Plasmolyse
(c) Remain unchanged (d) Become turgid

119. Osmoscope is used for:
(a) Measuring O.P. (b) Measuring T.P.
(c) Measuring ψ (d) Demonstration of osmosis

120. Osmosis means:
(a) Movement of molecules from higher concentration to lower concentration
(b) Uptake of water by roots
(c) Passage of solvent from a weaker solution to stronger solution across a semipermeable membrane
(d) Passage of solvent from a weaker to a stronger solution

121. The main difference between active and passive transport across cell membrane is that: (CBSE 1993)
    (a) Active transport is more rapid than passive
    (b) Passive transport is non-selective
    (c) Passive transport is due to the concentration gradient across the cell membrane whereas active transport is due to metabolic energy
    (d) Passive transport is confined to anions, whereas active transport is confined to cations only

122. All the following involves osmosis except: (AIIMS 1992)
    (a) Movement of water from soil to root
    (b) Movement of water from root hairs to endodermis and pericycle
    (c) Movement of water between xylem elements
    (d) Movement of water from xylem to mesophyll cells of leaves

123. D.P.D. of a plasmolysed cell is:
    (a) Zero (b) Equal to O.P.
    (c) T.P. (d) Equal to W.P.

124. If cells are kept for sometime in 1 M solution of sucrose and 1M solution of NaCl. The water potential (ψ_w) of the cells kept in: (AMU 1992)
    (a) Sucrose solution will be greater
    (b) NaCl solution will be greater
    (c) Both will be equal
    (d) Sucrose solution would be lower and NaCl solution would be greater

125. Water is absorbed when outside solution is: (AFMC 1993)
    (a) Hypertonic (b) Hypotonic
    (c) Isotonic (d) None of these

126. The pressure exerted by a swollen vacuole on the cell wall is:
    (a) O. P. (b) W. P.
    (c) T. P. (d) D. P. D.

127. In seed germination, the first phenomenon takes place is: (MDAT Bihar 1995)
    (a) Diffusion (b) Osmosis
    (c) Imbibition (d) All of these

128. What is the direction of movement of water if two cells have the same O.P. but differ in T.P.?
    (a) No net flow
    (b) From lower T.P. to higher T.P.
    (c) From higher T.P. to lower T.P.
    (d) Data insufficient

129. Water potential in the leaf tissue is positive (+ve) during: (CBSE 1997)
    (a) Excessive transpiration (b) Low absorption
    (c) Low transpiration (d) Guttation

130. The process of osmosis involves: (CPMT 1990)
    (a) Movement of solute through a semipermeable membrane
    (b) Movement of solvent through a semipermeable membrane
    (c) Movement of solution through a semipermeable membrane
    (d) None of the above

131. In soil, water available for roots is: (CBSE 1991)
    (a) Capillary water (b) Hygroscopic water
    (c) Gravitational water (d) None of these

132. Actively growing plant tissues have a water content of:
    (a) 20–40% (b) 40–50%
    (c) 65–75% (d) 85–90%

133. The root hair absorbs water from the soil, when water potential of root cell is .... than the soil:
    (a) More (b) Equal
    (c) Lesser (d) More or less

134. 0.5 M sucrose solution develops a pressure of 15 bars in an osmometer, which of the following statement is wrong for such a solution? (MDAT Bihar 1990)
    (a) That its osmotic potential is –15 bars
    (b) That its water potential is –15 bars
    (c) That its pressure potential is –15 bars
    (d) That its osmotic pressure is + 15 bars.

*135. 0.1 M solution of a solute has a water potential of: (MPPMT 1995)
    (a) – 2.3 bars (b) 0 bar
    (c) 22.4 bars (d) + 2.3 bars

136. Which of the following statements is correct?
    (a) D.P.D. always has a positive value and water potential always has a negative value
    (b) D.P.D. always has a negative value and water potential always has a positive value
    (c) Both D.P.D. and water potential have always positive values
    (d) Both D.P.D. and water potential have always negative values

137. Osmosis involves:
    (a) Cell to cell movement of water
    (b) Movement of water through cortical cells
    (c) Active absorption of water through roots
    (d) All of the above

*138. Water absorption through roots can be increased by: (BHU 1991)
    (a) Increased transpiration
    (b) Increased rate of photosynthesis
    (c) Decreased transpiration
    (d) Decreased absorption of ions

*139. What happens when a formalin preserved filament of *Spirogyra* is placed in a hypertonic sugar solution?
    (a) It looses turgidity (b) It gains turgidity
    (c) It is plasmolysed (d) Nothing happens

140. By which of the following process water and nutrients are absorbed by the plants?
    (a) Diffusion (b) Osmosis
    (c) Active absorption (d) Transpiration

141. Imbibition process involves: (CPMT 1990)
    (a) Both diffusion and capillary action
    (b) Only diffusion
    (c) Only capillary action
    (d) None of the above

142. When beet root slices are washed and then placed in cold water, anthocyanin does not come out, because plasma membrane is: (AFMC 1990)
(a) Dead structure
(b) Permeable to anthocyanin
(c) Impermeable to anthocyanin
(d) Differentially permeable to anthocyanin

143. A cell placed in hypertonic solution plasmolyses, the space between the cell wall and plasmolysed contents is filled with: (BHU 1991)
(a) Water (b) Cell sap
(c) Hypertonic solution (d) Hypotonic solution

144. Which of the following demonstrates imbibition?
(a) A grape fruit in saturated solution
(b) A piece of rubber in kerosine oil
(c) A piece of wood in kerosine oil
(d) A piece of rubber in water

145. Root pressure is due to: (MPPMT 1993)
(a) Passive absorption
(b) Active absorption
(c) Increase in transpiration
(d) Increase in photosynthesis

146. Semipermeable membrane allows the diffusion of: (CPMT 1991)
(a) Solutes
(b) Solvent
(c) Both solutes and solvent
(d) None of the above

147. The flow of water from one cell to another is governed by: (CBSE 1992)
(a) Osmotic pressure
(b) Diffusion
(c) Diffusion pressure deficit (D.P.D.)
(d) Osmosis

148. If a cell is placed in a solution and the cell shrinks, the solution is:
(a) Clear (b) Isotonic
(c) Hypotonic (d) Hypertonic

149. Which statement is not correct?
(a) D.P.D. of pure water is zero
(b) In a fully turgid cell, wall pressure is maximum
(c) Water potential is given a negative sign
(d) In a flaccid cell, D.P.D. is zero

150. Seeds when soaked in water imbibe it because:
(a) Osmotic pressure inside the seed is low
(b) Seed coat contains lot of salts
(c) The process of absorption works
(d) There are many vacuoles in the endosperm

151. Turgidity of a cell is maintained by:
(a) Diffusion pressure (b) Wall pressure
(c) Osmotic pressure (d) Turgor pressure

152. Water will be absorbed by root hairs when the external medium is:
(a) Isotonic (b) Viscous
(c) Hypotonic (d) Hypertonic

153. If a cell A with D.P.D. = 5 atm. is surrounded by many cells with D.P.D. = 4 atmosphere:
(a) The net movement of water will be from cell A to the surrounding cells
(b) The net movement will be from the surrounding cells to cell A
(c) Water movement will depend on other unknown factors
(d) Water will not move at all

154. Root hairs cells under ordinary conditions typically have a water potential in the range of:
(a) 1 to 4 atmospheres (b) –1 to –4 atmospheres
(c) 1 to 2 atmospheres (d) –1 to 2 atmospheres

155. The direction and rate of water movement from cell to cell is based on: (CBSE 1992)
(a) W.P. (b) T.P.
(c) D.P.D. (d) Incipient plasmolysis

156. A higher plant cell, impregnated with cutin and suberin is placed in water, what would happen after 15 minutes? (BHU 1993)
(a) Cell size will increase (b) Cell size will decrease
(c) No change in the cell (d) Cell would be killed

157. Osmotic pressure is highest in: (Raj. PMT 1992)
(a) Halophytes (b) Mesophytes
(c) Xerophytes (d) Lithophytes

158. You are given three cells, a root hair, a cell of the inner cortical layer, and a cell of the mesophyll, arrange them in ascending order of D.P.D.:
(a) Root hair < mesophyll < cortical cell
(b) Root hair < cortical cell < mesophyll
(c) Cortical cell < mesophyll < root hair
(d) Mesophyll < root hair < cortical cell

159. Root cap has no role in water absorption because:
(a) It has no cells containing chloroplasts
(b) It has no root hairs
(c) It has no direct connection with the vascular system
(d) It has loosely arranged cells

160. The pressure exerted by cell wall to balance the turgor pressure is called:
(a) Wall pressure (b) Osmotic pressure
(c) D.P.D. (d) Imbibitional pressure

161. Absorption of water by roots is increased when:
(a) Transpiration rate is less
(b) Salt absorption is increased
(c) Transpiration rate increases
(d) Photosynthetic rate increases

162. The entry of water from the soil upto xylem elements of roots is because of:
(a) Ion concentration in water
(b) Turgor pressure
(c) Gradient of suction pressure
(d) Degree of imbibition

163. Purple cabbage leaves do not loose their colour in cold water but do so in boiling water because:
(a) The plasma membrane gets killed in boiling water
(b) Hot water can enter the cells readily

(c) The pigment is not soluble in cold water
(d) The cell wall is killed in boiling water

164. If you place a piece of tomato in concentrated solution:
(a) It would become limp due to loss of water from its cells
(b) It would become turgid due to absorption of water salt solution
(c) It would die
(d) The plant is rapidly respiring

165. Under given suitable conditions, the D.P.D. will be more than O.P.: (BHU 1992)
(a) When O.P. is equal to T.P.
(b) When O.P. is less than T.P.
(c) When O.P. is greater than T.P.
(d) When T.P. is negative

166. Active absorption of water by roots from soil is mainly affected by:
(a) Osmotic concentration of cell sap
(b) Tension of cell sap due to transpiration
(c) Sucking power of the root hairs
(d) Typical tissue organization

167. The factor affecting the water potential is:
(a) Solute concentration (b) External pressure
(c) Both (a) and (b) (d) None of these

168. When a plant cell is placed in a solution which is hypotonic to the cell sap, which of the following conditions will not apply?
(a) The wall pressure of the cell will fall
(b) The cell will become turgid
(c) The suction pressure of the cell sap will fall
(d) The water potential of the cell sap will rise

169. The process of osmosis ceases when:
(a) Water concentrations become equal
(b) The leaves fall
(c) Solutions are not isotonic
(d) There is no light

170. A cell increases in volume when it is placed in a:
(a) Isotonic solution (b) Hypertonic solution
(c) Hypotonic solution (d) None of these

171. Ascent of sap mainly depends upon:
(a) Forces of cohesion (b) Forces of adhesion
(c) Suction pressure (d) All of these

172. What is the D.P.D. of cell, which is having osmotic pressure of 9 bars and turgor pressure 6 bars?
(a) 15 bars (b) –3 bars
(c) 3 bars (d) None of these

173. Which of the following is a rapid type of absorption?
(a) Salt absorption (b) Root absorption
(c) Active absorption (d) Passive absorption

174. If a plant cell is immersed in water, the water continues to enter the cell until the:
(a) Amount of water is the same inside the cell as outside
(b) Diffusion pressure is the same inside the cell as outside
(c) Conc. of the salt is the same inside the cell as outside
(d) Cell bursts

175. In the process of osmosis in the cell:
(a) Only cell wall acts as a membrane
(b) Only the outer most layer of protoplasm acts as a membrane
(c) Both cell wall and protoplasm act as a membrane
(d) Entire protoplast act as a membrane

176. If a cell is reduced in size when placed in a solution, the solution is:
(a) Hypotonic (b) Hypertonic
(c) Saturated (d) Weak

177. What is the osmotic relationship of a plant cell when it is put in an isotonic solution?
(a) Exosmosis (b) No net movement
(c) Endosmosis (d) None of these

178. Which of the following statement is not correct?
(a) Water and inorganic salts are taken in simultaneously by root hairs
(b) Plants absorb only one thing at a time, water or inorganic salt
(c) Plants absorb excess quantity of water
(d) Plants take in small quantity of water

179. The actual pressure with which water enters into the cell is called:
(a) W.P. (b) O.P.
(c) D.P.D. (d) Diffusion

180. A cell placed in strong salt soln. will shrink because:
(a) Salt water enters the cell
(b) Water comes out by exosmosis
(c) Cytoplasm will decompose
(d) Mineral salt will break the cell wall

181. The real force causing entry of water into a cell from other cells is:
(a) Diffusion pressure deficit
(b) Turgor pressure
(c) Osmotic pressure
(d) Wall pressure

182. "Osmosis is the diffusion of a solution of a weaker concentration into a soln. of a higher concentration, when both are separated by a semipermeable membrane." What is the error in this statement?
(a) The exact concentrations are not indicated
(b) There is no mention of D.P.D.
(c) The movement of water molecules is not specified
(d) The behaviour of the semipermeable membrane is not specified

183. That the cell wall is permeable membrane can be best deduced from the passage of water and mineral salts from:
(a) Root hairs into cortical cells
(b) Cortical cells into the pericycle
(c) Soil into root hairs
(d) Pericycle cells into tracheal elements

184. When a cell is fully turgid its:
(a) O.P. = zero (b) D.P.D. = O.P.
(c) D.P.D. = zero (d) S.P. = T.P.

185. How can grass be removed from a field without digging?
(a) By spraying grass with auxins
(b) By applying NaCl in excess
(c) By use of cytokinins
(d) Not possible without digging

186. An example of a selective permeable membrane is:
(a) Cell wall (b) Mitochondrial membrane
(c) Chloroplast membrane (d) Plasmalemma

187. Process of endosmosis stops:
(a) When water concentration becomes equal
(b) When solutions become isotonic
(c) When the leaves fall
(d) When there is no light

188. Which is the measure of free energy?
(a) D.P.D. (b) Osmotic pressure
(c) Water potential (d) None of these

189. Mark the correct statement:
(a) Osmotic pressure of 1M NaCl solution is twice than of 1M sugar solution
(b) Osmotic pressure of 1M NaCl solution is half as compared to O.P. of 1M sugar solution
(c) Both the solutions have equal O.P.
(d) None of the above is correct

***190.** A man supplied excess fertilizer and watered the grass well. After sometime the leaves turn brown because: **(CPMT 1993)**
(a) Osmosis occurs in root and the plant dies
(b) Fertilizer is drained in lower layer of soil
(c) It decreases photosynthesis
(d) Due to water logging soil

191. Osmosis is: **(EAMCET 1994)**
(a) Diffusion of solvent (b) Diffusion of solute
(c) Imbibition of solution (d) None of these

192. Soil water potential is measured with the help of instrument: **(CPMT 1992)**
(a) Porometer (b) Tensiometer
(c) Paedometer (d) Vacuum gauge

193. Cell A has osmotic potential of –20 bars and pressure potential of + 6 bars. What will be its water potential? **(CPMT 1992)**
(a) – 14 bars (b) + 14 bars
(c) – 20 bars (d) + 20 bars

194. Osmotic pressure is represented by:
(a) π (b) ψ
(c) λ (d) None of these

195. An innovative professor who wanted to give a live demonstration of a physiological process, filled a glass bottle with previously moistened mustard seeds, screwcapped the bottle and kept it away in corner and resumed his lecture. Towards the end of the lecture, there was a sudden explosion with glass piece of the bottle thrown around. Which of the following phenomenon did the professor want to demonstrate? **(CBSE 1990)**
(a) Diffusion (b) Imbibition
(c) Osmosis (d) Anaerobic respiration

196. Absorption of water and minerals in submerged hydrophytes takes place through: **(MPPMT 1991)**
(a) Roots (b) Leaves
(c) Stem (d) Outer surface of plant body

197. Conduction of sap in plants occurs through :
(a) Heart wood (b) Sap wood
(c) Xylem (d) All of these

198. Root system in a plant is well developed: **(CBSE 1990)**
(a) Due to deficiency of auxins
(b) Due to deficiency of cytokinins
(c) Due to deficiency of minerals
(d) For increased absorption of water

199. Water potential of a cell is lowered by:
(a) Addition of solutes (b) Increasing temperature
(c) Addition of water (d) Decreasing the temperature

200. Water potential is the measure of:
(a) Tendency of water to evaporate
(b) Tendency of water to move from one place to another
(c) Tendency to condense
(d) None of the above

201. Osmotic pressure in a vacuolated plant cell is usually: **(BHU 1991)**
(a) Less than D.P.D. (b) More than D.P.D.
(c) Equal to T.P. (d) Equal to W.P.

202. The osmotic potential of a solution is denoted by the symbol: **(AIIMS 1996)**
(a) ψx (b) $\Delta\psi$
(c) ψp (d) ψs

203. According to one vital force theory, ascent of sap is due to active pulsation of innermost layer of cortex (just outside the endodermis). This theory was given by: **(MPPMT 1991)**
(a) J.C. Bose (b) Dixon
(c) Strasburger (d) Saels

204. If cohesion–tension transpiration theory is correct then a break in water column in xylem vessels: **(AIIMS 1997; Manipal 1997)**
(a) Should cause the mesophyll cells to become flaccid and result in wilting of leaves
(b) Should increase the water contents of leaves
(c) Should have no effect at all
(d) Should increase the rate of photosynthesis

205. The magnitude of diffusion pressure deficit in non-turgid cell is equal to: **(MPPMT 1992)**
(a) Osmotic pressure – wall pressure or Turgor pressure
(b) Osmotic pressure + wall pressure
(c) Turgor pressure
(d) Osmotic pressure

206. Endosmosis of water occurs when in comparison with the outer solution, the water potential of cell sap: **(AMU 1996)**
(a) Higher (b) Lower
(c) Equal (d) None of these

207. The rate of absorption of water is slow at temperature near freezing point because: **(AMU 1997)**

(a) It is mainly a metabolic process
(b) Cell membrane becomes more
(c) Growth of cells stop
(d) Transpiration is retarded

208. The phenomenon of uptake of water at the expense of energy by the cell and usually against the osmotic gradient is known as: (Pondicherry 1992)
(a) Osmosis (b) Active absorption
(c) Passive absorption (d) Imbibition

209. The restoration of turgidity in a plasmolysed cell, when placed in a hypotonic solution is caused by: (AMU 1997)
(a) Hydration (b) Electrolysis
(c) Plasmolysis (d) Deplasmolysis

210. Transpiration–cohesion–tension theory operates in: (AIIMS 1993)
(a) Active absorption (b) Passive absorption
(c) Both active and passive (d) None of these

211. With increase in turgidity of a cell surrounded by water the wall pressure will: (CBSE 1997)
(a) Increase (b) Decrease
(c) Fluctuate (d) Remain unchanged

212. The water potential and osmotic potential of pure water are: (CBSE 1998)
(a) 100 and zero (b) Zero and zero
(c) 100 and 100 (d) Zero and 100

213. If a cell A with D.P.D. 4 bars is connected to cells B, C, D, whose O.P. and T.P. are respectively 4 and 4, 10 and 5 and 7 and 3 bars, the flow of water will be: (CBSE 1998)
(a) C to A, B and D (b) A and D to B and C
(c) A to B, C and D (d) B to A, C and D

*214. Girdling experiment cannot be performed in sugar cane because: (AFMC 1998)
(a) It cannot withstand injury
(b) Vascular bundles in it are scattered
(c) Phloem in it situated internal to xylem
(d) Sugar cane plants are too delicate

215. Water potential in a cell of root hair absorbing water is: (CBSE 1999)
(a) Zero
(b) Less than zero
(c) More than zero
(d) More than that of soil water

216. When a fully turgid cell is placed in highly concentrated solution, it: (BHU 1999)
(a) Gets plasmolysed and some concentrated solution fills in the gap between cell membrane and cell wall
(b) Gets deplasmolysed
(c) Remains as such
(d) Anything may happen

*217. At incipient plasmolysis, water potential (ψ_w) is equal to: (AIIMS 2000)
(a) $\psi_s + \psi_p$ (b) ψ_s
(c) $\psi_s + \psi_p + \psi_m$ (d) $\psi_p + \psi_m$

218. Cohesive force is associated with: (CPMT 2001)
(a) Transpiration (b) Ascent of sap
(c) Absorption of water (d) None of these

219. When water moves through a semipermeable membrane then which of the following pressure develops? (CBSE 2001)
(a) O.P. (b) S.P.
(c) T.P. (d) W.P.

220. Addition of a solute to pure water causes: (MPPMT 2001)
(a) Negative water potential
(b) More negative water potential
(c) Positive water potential
(d) More positive water potential

221. Most water absorption in plants takes place through: (MPPMT 2001)
(a) Root cap (b) Root apex
(c) Root hair zone (d) Meristematic zone

222. Which plant is ideal to demonstrate ascent of sap? (CPMT 2002)
(a) Rose plant (b) Balsam plant
(c) Coconut plant (d) Cucumber plant

223. The uniformly sweet taste of coffee or tea is due to: (JIPMER 2002)
(a) Spreading (b) Permeability
(c) Distribution (d) Diffusion

224. What will be the direction of net osmotic movement of water if a solution 'A', enclosed in a semipermeable membrane, having an osmotic potential of – 30 bars and turgor pressure of 5 bars is submerged in a solution 'B' with an osmotic potential of – 10 bars and 0 turgor pressure? (CET Karnataka 2002)
(a) Equal movement in both directions
(b) B to A
(c) No movement
(d) A to B

225. Change in diffusion pressure of a pure solvent when it is added with a solute is called: (Raj. PMT 2001)
(a) Osmosis (b) Diffusion
(c) D.P.D. (d) Imbibition

226. Exchange of substances between individual cells and their environments takes place by: (BHU 2002)
(a) Osmosis (b) Diffusion
(c) Active transport (d) All of these

227. The risk of spoilage is less in salted pickles because of: (EAMCET 2002)
(a) Guttation (b) Plasmolysis
(c) Imbibition (d) Diffusion

228. Which one of the following is not associated with ascent of sap in tall trees? (EAMCET 2002)
(a) Cohesion and adhesion of water molecules
(b) Continuity of water column
(c) Pressure in tracheary elements
(d) Transpiration pull

229. When a plasmolysed cell is placed in a hypotonic solution then water will move inside the cell. Which force causes this? (Raj. PMT 2002)
(a) D.P.D. (b) O.P.
(c) W.P. (d) None of these

230. In osmosis there is a movement of: (CPMT 2003)
(a) Solute only (b) Solvent only
(c) Both (a) and (b) (d) Neither solute nor solvent

231. O.P. of a solution is: (DPMT 2003)
(a) Greater than pure solvent
(b) Less than pure solvent
(c) Equal to the pure solvent
(d) Less than or greater than pure solvent

232. A sufficient atmospheric pressure required to push the water upto the top of tall plants must be: (BV Pune 2003)
(a) 6 atm (b) 2 atm
(c) 20 atm (d) All of these

233. The membrane which allows passage of certain substances more readily than others is termed as: (BV Pune 2003)
(a) Impermeable (b) Semipermeable
(c) Permeable (d) Selectively permeable

234. Solution outside a cell has higher concentration than cytoplasm. Then the solution is: (AFMC 2003)
(a) Isotonic (b) Acidic
(c) Hypotonic (d) Hypertonic

235. The continuity of water column in xylem is maintained due to: (Manipal 2003)
(a) Evaporation of water (b) Cohesive property of water
(c) Presence of air bubbles (d) None of these

ANSWERS

1—b	2—c	3—d	4—c	5—a	6—b	7—d	8—c	9—a	10—c	11—c	12—c
13—b	14—d	15—b	16—c	17—d	18—c	19—d	20—c	21—b	22—c	23—c	24—c
25—a	26—a	27—c	28—b	29—b	30—a	31—c	32—b	33—b	34—b	35—b	36—b
37—b	38—b	39—b	40—d	41—c	42—d	43—c	44—c	45—b	46—c	47—c	48—b
49—d	50—b	51—c	52—c	53—b	54—b	55—b	56—d	57—d	58—b	59—b	60—d
61—d	62—c	63—a	64—d	65—d	66—c	67—b	68—a	69—c	70—b	71—c	72—c
73—b	74—c	75—d	76—d	77—b	78—d	79—a	80—d	81—c	82—a	83—d	84—c
85—a	86—a	87—b	88—d	89—b	90—b	91—a	92—a	93—c	94—a	95—a	96—c
97—a	98—d	99—c	100—d	101—c	102—a	103—b	104—a	105—d	106—c	107—b	108—d
109—b	110—c	111—a	112—b	113—b	114—a	115—c	116—c	117—b	118—c	119—d	120—c
121—c	122—c	123—b	124—a	125—b	126—c	127—c	128—c	129—c	130—b	131—a	132—d
133—c	134—c	135—a	136—a	137—d	138—a	139—d	140—c	141—a	142—b	143—c	144—b
145—b	146—b	147—c	148—d	149—d	150—c	151—d	152—c	153—b	154—b	155—c	156—c
157—a	158—b	159—b	160—a	161—c	162—c	163—a	164—a	165—d	166—a	167—c	168—a
169—a	170—c	171—d	172—c	173—d	174—b	175—d	176—b	177—b	178—b	179—c	180—b
181—a	182—c	183—c	184—c	185—b	186—d	187—b	188—c	189—a	190—a	191—a	192—b
193—a	194—a	195—b	196—d	197—b	198—d	199—a	200—b	201—b	202—d	203—a	204—a
205—a	206—b	207—d	208—b	209—d	210—b	211—a	212—b	213—d	214—b	215—b	216—a
217—b	218—b	219—a	220—a	221—c	222—b	223—d	224—b	225—c	226—d	227—b	228—c
229—a	230—b	231—a	232—c	233—d	234—d	235—b					

EXPLANATION OF SELECTED QUESTIONS (*)

8. When no change occurs in a cell after placing it in 0.5 M sugar solution, it means the solution is isotonic and thus concentration of cell sap is also 0.5 M.

21. Sucrose is non-ionizing substance whereas NaCl is ionizing and osmotic pressure of a solution of ionizing substance is greater than that of equimolar concentration of a non-ionizing substance.

44. Manometer is a device used for measuring root pressure.

109. In a fully turgid cell, O.P. is equal to T.P. and thus D.P.D. is zero.

117. Water potential of a cell protoplasm is equal but opposite in sign to D.P.D.

118. Alcohol treatment causes loss of selective permeability of membrane and hence there will be no change when this alcohol treated cell will be placed in hypertonic solution of sucrose.

135. 1 M solution of a solute at normal temperature and pressure has water potential −23 bars, hence 0.1 M solution will have water potential −2.3 bars.

138. Water absorption through roots (passive absorption) can be increased by increased transpiration as it is due to transpiration pull.

139. In formalin preserved *Spirogyra* filament, selective permeability of P. membrane is lost and hence no effect on placing in hypertonic solution.

190. After adding excess of fertilizer and irrigation in grass field, the outer soil solution becomes hypertonic and hence exosmosis occurs which leads to plasmolysis of cells and hence wilting which leads to drying and browning of leaves.

214. Sugar cane is a monocot, where scattered vascular bundles occur in stem and hence girdling experiments cannot be performed in it.

217. At incipient plasmolysis, the cell wall exerts no pressure on the cell contents and thus wall pressure or pressure potential (ψ_p) is zero and thus water potential is equal to solute potential (ψ_s) as $\psi_w = \psi_s + \psi_p$.

a b c d e f i j k l m n o
p q r s t u v w x y z
a b c d e f g h i j k l m n o p q r s t u v w x y z

22

Plant Physiology (II)

TRANSPIRATION, MINERAL NUTRITION, MINERAL SALT ABSORPTION

- **Transpiration :** Meaning, differences between transpiration and evaporation, magnitude of water loss in transpiration, types of transpiration, transpiration ratio, stomata, distribution of stomata on leaf epidermis, mechanism of stomatal movements, scotoactive stomata, daily periodicity of stomatal opening, factors affecting transpiration, antitranspirants, significance of transpiration; Guttation, differences between transpiration and guttation.
- **Mineral nutrition :** Meaning, composition of plant ash, general functions of mineral elements, critical elements, study of significance of elements for plants, specific roles of different elements, Liebig's law of minimum.
- **Mineral salt absorption :** General, mechanism of mineral salt absorption, factors affecting mineral salt absorption.

TRANSPIRATION

Most of the water absorbed by roots of plant is lost from aerial parts of the plant. (**Loss is upto 95% and only 5% is used by plant**)

This loss of water in vapour form from living tissue of aerial parts of the plants, is called **transpiration.**

Evaporation is another process for loss of water from any free surface. Main differences between transpiration and evaporation are as:

S. No.	Transpiration	Evaporation
1.	It is a **physiological process** which occurs in plants.	It is a **physical process** from any free surface.
2.	Only from living cells.	Both from living and non-living surface.
3.	Transpiration is through epidermis and specially through stomata.	From free surface.
4.	Forces like V. P., T. P., O. P., are involved.	No such forces are involved.
5.	It is responsible for preventing the surface of plant (leaves) from drying or it keeps the surface wet.	It leads to dryness of surface.

Magnitude of water loss in transpiration

Water lost in transpiration is considerable. A beech plant looses water every day equal to 5 times the fresh weight of its leaves and for an acre of beech plants, the water lost in transpiration per day is 3000 gallons.

Magnitude of transpiration in some other plants are:

Cowpea (*Vigna sinensis*)	—	13 gallons of H_2O/plant/growing season
Potato (*Solanum tuberosum*)	—	25 gallons of H_2O/plant/growing season
Wheat (*Triticum aestivum*)	—	25 gallons of H_2O/plant/growing season
Tomato (*Lycopersicum esculentum*)	—	34 gallons of H_2O/plant/growing season
Corn (*Zea mays*)	—	54 gallons of H_2O/plant/growing season

Types of transpiration

It is mainly from leaves (*i.e.*, foliar transpiration).

In general, transpiration is of following 3 types:

1. Stomatal transpiration : **80–90%** of total water lost in transpiration is through specialized pores (stomata) on leaf surface, called stomatal transpiration.

2. Cuticular transpiration : Directly through cuticle. 3–9% of total transpiration (in rare cases upto 20%) occurs through the cuticle. Thicker is the cuticle, lesser will be the transpiration.

3. Lenticular transpiration : *i.e.,* through lenticels or pores present in woody stem and in some fruits. It accounts for only 0·1% of total transpiration (rarely upto 1%).

Transpiration ratio

It can be defined as the amount of water lost through transpiration per unit of dry matter produced during growing season of the plant.

- The transpiration ratio varies from one plant species to another and also under different conditions. Plants growing in deserts have the highest transpiration ratio (5000).

Stomata

Stomata are **main avenues** for transpiration. Stomata are widely distributed in plant kingdom except algae and fungi (Thallophyta).

Stomata are minute specialized pores generally present on leaf epidermis (although stomata in some cases are found in herbaceous stem).

- Each stoma is bordered by two specialized epidermal cells called **'guard cells'**, which are generally kidney shaped or bean shaped or reniform but in grasses, guard cells are **dumb-bell shaped or bar-bell shaped**.
- When fully open, the stomatal pore measures 3–12 μ in width and 10–40 μ in length.
- Number of stomata per square cm is 1,000–60,000 in different plants sps. (14–1065/sq. mm). The number of stomata per unit area of leaf is called stomatal frequency. Stomatal frequency of trees and shrubs is higher than those of herbs.

Whatever may be the number of stomata, these are so small that they occupy only 1–2% of total leaf area, when fully open.

- Salisbury gave the term stomatal index. According to him, there occurs a correlation between number of stomata and number of epidermal cells per unit area which is called stomatal index (I).

$$I = \frac{S}{E+S} \times 100 \left\{ \begin{array}{l} \text{where } S \to \text{Number of stomata per unit area} \\ E = \text{Number of epidermal cells per unit area} \end{array} \right.$$

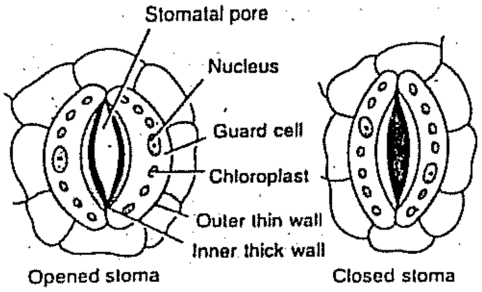


Fig. 22.1. Open and closed stomata

- Stomata are mainly present on under surface or lower surface or dorsal surface or abaxial surface. The cell walls of guard cells adjacent to pores is much thicker and inelastic and outer walls are thinner and more elastic.

Further guard cells are specialized epidermal cells which **contain chloroplasts** (in rest of epidermal cells, chloroplasts are absent). But chloroplasts of guard cells are capable of poor photosynthesis (there is absence of RuBP-carboxylase enzyme, although both PS-I and PS-II are present in chloroplasts of guard cells).

- Guard cells are surrounded by other specialized epidermal cells called **subsidiary cells or accessory cells.**
- Opening and closing of stomata (stomatal movements) are governed by change in O.P. or turgidity of guard cells, *i.e.,* when guard cells are **turgid,** stomata open and when **flaccid,** stomata close.

Distribution of stomata on leaf epidermis

There are five categories on the basis of distribution:

1. **Apple or Mulberry type :** Here stomata are present on abaxial or lower (dorsal) surface of leaves, *e.g.,* apple, peach, mulberry, walnut, etc.
2. **Potato type :** Stomata are more on lower surface and fewer on upper surface, *e.g.,* potato and beans, etc.
3. **Oat type :** Here stomata are equal on both surfaces, *e.g.,* wheat, rice, maize, oat, etc.
4. **Water lily type :** Stomata are mostly present on upper surface of leaves, *e.g.,* all free floating hydrophytes (hydrophytes with floating leaves).
5. **Potamogeton type :** Either stomata absent or if present these are non-functional, *e.g.,* all submerged hydrophytes.

Mechanism of stomatal movements

Stomatal movements are due to changes in osmotic pressure or turgidity of guard cells. Different theories of stomatal movements have been given as:

1. Photosynthetic production theory

Given by Von Mohl (1856). Chloroplasts of guard cells produce sugars (osmotically active substances) due to photosynthesis in light → increased O.P. of guard cells → endosmosis into guard cells → guard cells turgid → **stomata open.**

Objection : Increasing the CO_2 concentration around the leaves should lead to wide opening of stomata but there occurs partial closure. Later on it was said that chloroplasts of guard cells are capable of poor photosynthesis.

2. Starch ⇌ sugar interconversion theory

First given by **Lloyd** (1908).

According to this theory, amount of sugars in guard cells increases in day time, whereas amount of starch increases during night and stomatal movements are due to interconversion of starch and sugar. It was supported by

Loftfield. Further **Sayre** reported that stomata open when pH is higher (7) and close when pH is low (5), *i.e.*, **high pH favours stomatal opening.**

Again high pH is seen during day time and low during night.

- o In high pH during day time, starch is converted into sugars and at low pH at night, sugar is converted into starch and this was proved when **Yin** and **Tung** reported **phosphorylase** enzyme in guard cells, which is capable of this interconversion.

$$\underset{\text{(Stomata close)}}{\text{Starch} + \text{ip}} \underset{\text{pH (5)}}{\overset{\text{Phosphorylase}}{\overset{\text{pH (7)}}{\rightleftharpoons}}} \underset{\text{(Stomata open)}}{\text{Glucose}-1-PO_4}$$

- o **Steward** (1964) put forward an objection that stomatal opening does not occur unless Glucose $-1-PO_4$ is further converted into Glucose as Glucose$-1-PO_4$ is as osmotically active as inorganic phosphate (ip) on other side of the equation.

Objections

(i) Starch has never been reported from guard cells of onion.

(ii) Starch-sugar interconversion is a slow process which cannot account for rapid stomatal movements.

(iii) Sugar has never been found in free state in guard cells of open stomata.

(iv) Enzyme phosphorylase catalyses the reaction only in forward direction and not in backward direction.

3. Active K⁺ ion transport theory

This was initially given by **Fujino** (1959) and later modified by **Levitt** (1974), which was supported by **Raschke** and **Bowling** (1976). Now this theory is known as K^+ **ion transport and hormonal regulation theory.**

When K^+ ions **into** the guard cells—**Stomata open**

and when K^+ ions **out—Stomata close**

- o **This is the most accepted modern theory** of stomatal movements nowadays.

(A) During day time :

Malic acid is formed in guard cells
↓ Dissociates into
H^+ + malate ions
↓ K^+ ion exchange from subsidiary cells
K^+ + malate ions in guard cells
↓
O. pressure of guard cells increased
↓
Endosmosis into guard cells
↓
Guard cells turgid
↓
Stomata open

- o Further **stomatal opening is active process** (requiring energy).

(B) During night or dark : CO_2 conc. increases in sub-stomatal cavities → ABA participation → K^+ ions exchange stopped → K^+ ions transported back into subsidiary cells → Decreased pH → Starch synthesized in guard cells → Decreased O.P. of guard cells → Exosmosis from guard cells → **stomata close**

So in stomatal closure there is **role of ABA.** Further stomatal closing is a passive process.

Scotoactive stomata

In most of the plants, stomata open during day time and close during night, such stomata are called **photoactive stomata,** but in some succulents (xerophytes) stomata open during night and close during day time. Such stomata are known as **scotoactive stomata.** This is a mechanism to reduce water loss due to transpiration. These are found in plants like *Opuntia, Aloe, Bryophyllum, Bigonia, Agave*, etc.

- ● In these plants **night acidification** occurs, *i.e.*, malic acid is synthesized during night due to incomplete oxidation of carbohydrates.
- ● In night

$$2C_6H_{12}O_6 + 3O_2 \longrightarrow \underset{\text{(Malic acid)}}{3C_4H_6O_5} + 3H_2O$$

↓

leads to **opening** of stomata.

- ● During day, this malic acid is oxidised to CO_2.

$$C_4H_6O_5 + 3O_2 \longrightarrow 4CO_2 + 3H_2O$$

This leads to **closure** of stomata.

- o Such plants are called **crassulacean acid metabolism** (CAM) plants as this mechanism was first reported in *Bryophyllum*, a member of family **Crassulaceae.**

Daily periodicity of stomatal opening

In most of the mesophytes, there are **photoactive stomata,** *i.e.*, opening during day time.

- o Maximum opening of stomata occurs at about 10.00 AM and 3.00 PM

(At 12.00 noon, partial closure of stomata occurs)

Factors affecting transpiration

(A) Plant factors or Internal factors

1. Root/shoot ratio : If water absorption lags behind transpiration, water deficit occurs in plant which leads to decrease in rate of transpiration.

- o In general, higher the root/shoot ratio, more will be the rate of transpiration.

2. Leaf area : In general more is the leaf area, more will be the transpiration.

- o On per unit area basis, smaller plants transpire at much higher rate as compared to larger plants.
- o Removal of leaves from a plant increases transpiration per unit area.

acids

night
dark

partial
closure

ABA

3. Leaf structure : Plants growing in dry conditions (xerophytes) develop some characters in leaves so as to reduce rate of transpiration like thick cuticle, thick epidermal cell wall, sunken stomata, waxy covering, hairy (mealy) covering, etc.

- ○ If adequate water supply is given to xerophytes, then rate of transpiration per unit area will be more in xerophytes as compared to mesophytes because number of stomata per unit area is more in xerophytes. Further venation of xerophytic leaves is much developed.

(B) External or Environmental factors

1. Light : Light is very important factor as most of the stomata open during day time.

- ○ Maximum opening of stomata occurs in red light (660 nm), followed by blue light (445 nm) and no opening occurs in green light, UV-light and far red light. So action spectrum of transpiration is similar to that of photosynthesis.

2. Relative Humidity (R.H.) : It is the ratio of amount of vapours present in atmosphere to total amount of vapours which the air can hold at existing temperature.

If R.H. is low then rate of transpiration is more and if R.H. high, transpiration is less.

- ○ In fact, transpiration depends upon difference in vapour pressure of internal atmosphere of leaf and external environment (*i.e.*, V.P. gradient) and it is, therefore, that no transpiration occurs when stomata are fully open but relative humidity is 100%.

3. Temperature : Increase in temperature leads to opening of stomata even in night (dark) but within a certain physiological range. Again very high temperature leads to closing of stomata even in day (**mid-day closure**).

4. Wind : Wind increases the rate of transpiration by drying the external environment and hence increasing V.P. gradient between external environment and internal environment of leaf, but very high wind velocity decreases transpiration by lowering temperature.

5. Atmospheric pressure : As we go up on hills, atmospheric pressure decreases and hence transpiration increases but simultaneously transpiration is decreased by low temperature and hence overall result is normal.

6. Availability of water : If water is not available in soil, no absorption and hence no transpiration due to water deficit conditions.

Antitranspirants

Such substances which reduce the rate of transpiration without affecting other physiological processes, are called antitranspirants.

Initially colourless plastics, silicon oils, low density waxes, etc., were used as antitranspirants, but these did not prove to be good.

Nowadays, phenyl mercuric acetate or PMA (although slightly toxic) in 10^{-4} M conc. for 2 weeks, aspirin, salicylic acid, ABA (abscisic acid) and CO_2 at slightly higher conc. (more than 0·03%) are being used as antitranspirants.

Some points to remember

- ○ Stomatal pore is measured with the help of instrument called **porometer.**
- ○ Rate of transpiration is measured by **potometer**, *e.g.*, Ganong's potometer, Farmer's potometer, Darwin's potometer, etc. Principle of working of all potometers is that **absorption is proportional to transpiration.**
- ○ **Cobalt chloride paper method is used to compare rate of transpiration on two surfaces of leaf.**

Significance of transpiration

Transpiration is controversial subject. Some consider it useful and others as harmful process.

1. Supposed role in upward movement of water and water absorption : But opposite view workers say that if there were no transpiration, there would have been no need of ascent of sap. Further plants even maintain their turgidity in absence of transpiration.

2. Supposed role in mineral salt absorption : But opponents say that there should be high ash content in the tops of the plants with high transpiration. Further mineral deficiency should occur in plants with low transpiration, but this does not occur.

3. Supposed role in regulation of temperature or Cooling effect : But it has been seen that there is no high temp. injury in plants with low transpiration (*i.e.*, in xerophytes).

It is now established that transpiration is harmful to plants and it leads to wilting and continuous permanent wilting may lead to death of the plant. Thus the plants are modified variously to reduce transpiration and some plants shed their all leaves to reduce transpiration.

- ○ Transpiration is actually consequence of basic facts of plant anatomy. Loosely arranged mesophyll cells which open outside through stomata are meant for gaseous exchange but it has given rise to a dreadful phenomenon of transpiration.

So Curtis (1926) has rightly called that **"transpiration is a necessary evil".**

GUTTATION

In some herbaceous plants like garden nasturtium (*Tropaeolum najas*), oats, barley, rice and *Colocasia*, etc., drops of water come out from edges or margins of leaves during night or early morning.

Loss of water in this manner from margins of leaves is called guttation. It occurs in warm, moist soils with humid environment or when warm days are followed by cool nights.

- ○ In general, guttation occurs when transpiration rate is very low as compared to rate of water absorption. Due to this, root pressure is developed and water is pushed out through specialized pores at vein endings called **hydathodes.**

(~~So guttation is~~ not due to activity of hydathodes but due to root pressure.)

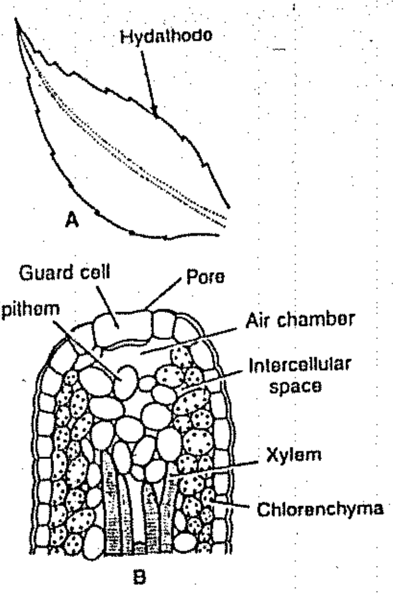


Fig. 22.2. A. Entire leaf showing hydathodes
B. V.S. of leaf showing hydathode

- Water lost in guttation per plant/night is generally up to 100 mL but in *Colocasia antiquorum*, loss of water per plant by guttation is about **200 mL** (maximum).
- Water lost in guttation is **impure water**, *i.e.*, a dilute solution of different inorganic and organic substances like aspartic acid, asparagine, salts and sugars. These substances are seen on leaf surface after drying. These salts sometimes are redissolved back into leaves and cause **'salt injury'**.

Main differences between transpiration and guttation are

S. No.	Transpiration	Guttation
(i)	Loss of water is in vapour form.	Loss is in liquid form.
(ii)	It occurs during day time.	During night or early morning.
(iii)	Pure water.	Impure water.
(iv)	Through stomata or epidermis or cuticle or lenticels.	Through hydathodes.
(v)	Controlled phenomenon.	Uncontrolled phenomenon.
(vi)	Associated with regulation of temperature.	No such role has been given to guttation.

MINERAL NUTRITION

Green plants are autotrophic as they form their organic food themselves. This organic food is formed from inorganic substances taken up by plants from outside, which are present in soil in the form of minerals, which are known as **mineral elements or mineral nutrients** and this nutrition is called **mineral nutrition.**

- Carbon, oxygen and hydrogen are the **non-mineral elements.** Plants obtain carbon in the form of atmospheric CO_2, hydrogen mainly from H_2O and oxygen is obtained from air or H_2O. Nitrogen is peculiar in sense that it is obtained by plants from both mineral and non-mineral sources.
- **Woodward** (1699) reported that plants grow better in muddy water as compared to fresh rain water.
- **De Saussure** (1804) first of all demonstrated that plants obtain minerals from soil through root system.

Composition of plant ash or Various constituents of plants : Chemical analysis of plants show that they contain water and some solid substances.

- If dried plant parts are heated in silica crucible at 600°C, all organic substances vaporize and the remaining **plant ash contains only inorganic substances or mineral elements.**

Analysis of plant ash shows that about 92 mineral elements are present in different plants. Out of these, 30 elements are present in each and every plant and rest are in one or other plants. Out of these 30 elements, **16 elements** are necessary for plants and are called **essential elements,** which are as :

C, H, O, N, P, S, K, Mg, Ca, Fe, Cu, B, Zn, Mn, Mo and Cl.

- Criteria for essentiality of elements were first of all given by **Arnon.** Three criteria for essentiality are as follows:

1. Plant is not able to grow normally and hence **unable to complete its life cycle** in the absence of essential element.
2. It cannot be replaced by other element however, close it may be in periodic table, *i.e.*, it is **specific.**
3. It plays **direct role** in metabolism of plant.

Essential elements are divided into two main types:

(A) Macro elements or Major elements : Which are required by plants in larger amounts, *e.g.*, C, H, O, N, S, P, K, Ca, Mg.

(B) Micro elements or Minor elements or Trace elements : Which are required by plants in very small amounts, *i.e.*, in traces, *e.g.*, Fe, Cu, B, Zn, Mn, Mo, Cl.

(Generally less than 1 ppm)

- Some workers consider Fe as macro or major element.
- (**Tracer elements :** These are radioactive isotopes of elements, which are used to detect various metabolic pathways in plants, *e.g.*, C^{14}, N^{15}, P^{32}, S^{35}, etc.)
- Usual concentration of different elements in plants (% of dry wt) is:

C ⟶ 45%
O ⟶ 45%
H ⟶ 6%
N ⟶ 1.5%
K ⟶ 1%
Ca ⟶ 0·5%
Mg ⟶ 0.2%
P ⟶ 0.2%
S ⟶ 0.1%

Cl ⟶ 0.01%
Fe ⟶ 0.01%
Mn ⟶ 0.005%
B ⟶ 0.002%
Zn ⟶ 0.002%
Cu ⟶ 0.0001%
Mo ⟶ 0.0001%

General functions of mineral elements

1. Frame work elements : C, H, O which form main components, constitute frame work elements.

2. Protoplasmic elements : N, P, S along with C, H, O constitute components of protoplasm.

3. Maintenance of osmotic concentration : As cell sap contains different salts of elements dissolved in it, hence they maintain osmotic concentration.

4. Catalytic function : Elements like Cu, Fe, Mn, Mo, etc., act as co-factors of different enzymes.

5. Balancing effect : Elements like K, Ca, Mg counterbalance the toxic effect of different elements, hence play balancing role.

6. Responsible for permeability of cytoplasmic membranes : Specially monovalent cations.

7. Buffer action : Some elements maintain pH and thus have buffer action. Phosphate system acts as an important buffer.

Critical elements

Critical elements are the elements in which soil is generally deficient, *e.g.*, N, P and K. These are given in the form of chemical fertilizers.

Study of significance of different elements for plants

Essentiality of different elements can be detected by solution culture or sand culture methods, *i.e.*, withholding of any essential element leads to development of deficiency symptoms (Hunger signs). Different nutrient solutions or formulae are being used for growing the plants, *e.g.*, **Knop's formula, Pfiffer's formula, Hoagland's formula, Arnon's** formula, etc.

- **Soil less growth** (or **solution culture**) is called **hydroponics.** Here plants are grown with their roots dipped in a nutrient solution. This practice is being used in USA and Abu-dhabi for growth of the plants.
- **Sand culture :** Here plants are grown in inert sand + nutrient solution. Main advantage is that roots get natural environment and proper aeration.
- **Aeroponics :** In this practice, plants are grown with their roots bathed in nutrient mist. This method has been successfully used in growing *Citrus* and olive plants.

Specific roles of different elements

1. C, H, O (Frame work elements) : These are components of protoplasm and most of other organic compounds found in plants.

2. Nitrogen (N) : It is 4th most abundant element. Chief source of N for plants is **nitrates** of Ca and K. Some higher plants are capable of taking atmospheric N_2 with the help of bacteria. It is component of nucleic acids, proteins, chlorophyll and cytochromes. Deficiency causes poor root development, lower respiration rate, chlorosis of older leaves, etc.

3. Sulphur (S) : It is absorbed as **sulphate.** It is constituent of amino acids (cystein, cystine and methionine). Deficiency causes chlorosis of young leaves, retardation of cell division and suppression of fruit formation.

4. Phosphorus (P) : It is absorbed as **phosphate.** It is important constituent of nucleic acid, phospholipids, NADP, ATP, etc. Deficiency causes premature leaf fall and leaves become dark to blue-green in colour.

5. Calcium (Ca) : It is absorbed from soil in the form of its **nitrates and sulphates.** It is rich in older tissue and is the part of middle lamella. Further it stabilizes the structure of chromosomes. Deficiency causes disintegration of growing meristem, chlorosis along the margins and decreases amino acid and carbohydrate movement.

6. Potassium (K) : It is absorbed in form of its **nitrate** and **chloride.** It is essential for process of respiration and photosynthesis. It is also activator of many enzymes (over 40). It plays an important role in **stomatal movements.** Deficiency causes mottled chlorosis of leaves, plant growth remains stunted with shortening of internodes.

7. Magnesium (Mg) : It is important constituent of chlorophyll, thus is found in all green plants and essential for photosynthesis. It also helps in binding of ribosomal particles where protein synthesis occurs. It is also part of many enzymes of respiration.

8. Iron (Fe) : It is absorbed by plant in **ferrous form,** although some amount of ferric form may also be absorbed. It plays an important role in ETS, photosynthesis and respiration because iron is the **part of cytochromes.** It is also essential for chlorophyll synthesis.

9. Boron (B) : It is absorbed as **borate.** It facilitates **translocation of sugar** in plants. Deficiency causes death of shoot tip and suppression of flower formation, root growth is stunted and leaves becomes coppery in texture. Deficiency of boron causes some physiological diseases like **heart-rot of sugar beet, internal cork of apple, water cork in turnip, stem crack in celery and brown heart disease, etc.**

10. Manganese (Mn) : It is absorbed as its **oxide.** It is activator of several enzymes of **Krebs' cycle** like malic dehydrogenase. It is also activator of nitrite reductase. It is responsible for photolysis of H_2O during photosynthesis, synthesis of chlorophyll and IAA. Its deficiency causes many physiological diseases like **grey-speck of oats, marsh spot of pea, speckled yellow of sugar beet,** etc.

11. Zinc (Zn) : It is essential for synthesis of **tryptophan** amino acid, which forms IAA (Indole Acetic Acid). Deficiency causes chlorosis of older leaves.

- **Khaira disease of rice and white bud of maize** is due to zinc deficiency.

12. Copper (Cu) : It is the part of several oxidising enzymes and in higher conc., it is toxic. Deficiency causes necrosis of the tip of new leaves.

- **Die back of *Citrus* and reclamation disease of cereale and legumes and exanthema in fruit trees** are due to deficiency of Cu.

13. Molybdenum (Mo) : It is responsible for nodulation in legumes. It is part of nitrate reductase enzyme which helps in nitrogen fixation. Deficiency causes inhibition of fruit formation.

- **Whiptail disease of cauliflower** is caused by Mo deficiency.

14. Chlorine (Cl): It has important role in photosynthesis, specially in light reaction, *i.e.*, helps in **photolysis of water.**

Liebig's law of minimum: It states that the yield of the crop plant is determined by the amount of that essential element, which is present in minimum quantity, in proportion to demand of the plant.

MINERAL SALT ABSORPTION

Plants obtain minerals from soil where these are dissolved in soil solution or are present adsorbed to colloidal clay particles.

- Mineral salt absorption is **independent** of water absorption.
- Maximum mineral salt absorption occurs by **zone of elongation.** No mineral salt absorption occurs by root hair zone. Mineral salt absorption occurs directly by cells of epiblema and not by root hair.
- Mineral salts are absorbed mostly in form of ions, *i.e.*, anions and cations.

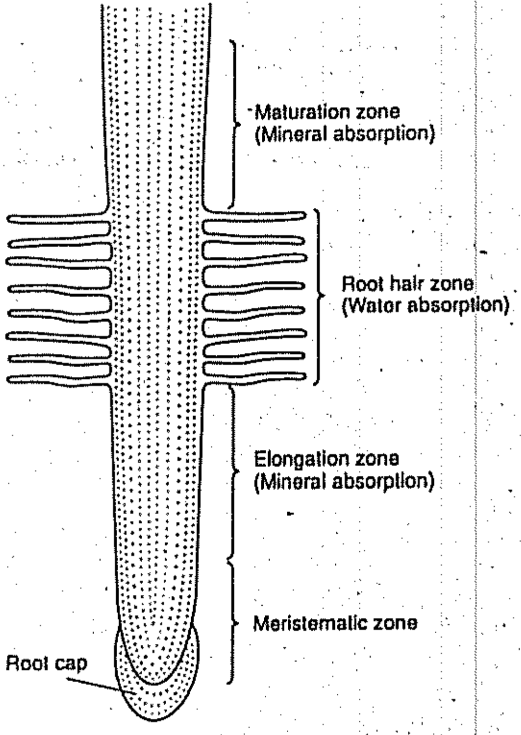

Maturation zone (Mineral absorption)
Root hair zone (Water absorption)
Elongation zone (Mineral absorption)
Meristematic zone
Root cap

Fig. 22.3. Zones of root responsible for mineral absorption

Mechanism of mineral salt absorption

(A) Passive salt absorption

When no metabolic energy is required and it is by (a) Free diffusion (b) Ion exchange (c) Donann's equilibrium—This accounts for accumulation of mineral salts against conc. gradient without participation of metabolic energy. Further this describes effect of fixed or indiffusible ions on inner surface of membrane.

(B) Active salt absorption

Here salt absorption occurs by utilizing metabolic energy. The main theory for active mineral salt absorption is **carrier** concept given by **Vanden Honert** (1932).

Two possible mechanisms of salt absorption based on "carrier concept" are:

(a) **Cytochrome pump hypothesis:** Given by **Lundegardh and Burstrom** (1933). According to this, there is close association between respiration and anion absorption and cytochrome (iron porphyrin) is responsible for active absorption of anions and cations are absorbed passively.

(b) **Protein-lecithin carrier concept:** Given by **Bennet-Clark** (1956). According to this, **protein-lecithin** acts as carrier for active absorption of both cations and anions.

Factors affecting mineral salt absorption

1. Temperature: Increase in temperature leads to increase in mineral salt absorption but very high temperature decreases salt absorption due to denaturation of protein carriers.

2. pH: In general decrease in pH leads to increase in anions absorption whereas increase in pH leads to increase in cations absorption.

3. O_2: Active mineral salt absorption is decreased by decrease in O_2 concentration.

4. Ageing: Salt absorption is decreased by increase in age of the roots due to **suberization.**

- Path of transport of mineral salts is **xylem.**

ions = cations + anions.

MULTIPLE CHOICE QUESTIONS

1. What amount of water absorbed by plants is lost in transpiration?
(a) 80% (b) 90%
[✓ (c) 95%] (d) 75%

2. Which statement is not correct regarding transpiration?
(a) Living cells are involved
(b) V.P., D.P., O.P. involved
(c) Causes dryness of surface
(d) Physiological process

3. Stomatal transpiration accounts for what % of water loss?
(a) 20% (b) 80–90%
(c) 70% (d) 75%

4. Which of the following lacks stomata?
(a) Angiosperms (b) Bryophytes
(c) Algae (d) Pteridophytes

5. Number of stomata/square cm of leaf is:
(a) 500–1000 (b) 1000–2000
(c) 1000–60,000 (d) None of these

6. Fully opened stomata of leaf occupies what % of leaf area?
(a) 0.5% (b) 5%
(c) 10% (d) 1–2%

7. Barbell shaped guard cells are found in:
(a) Legumes (b) Cucurbits
(c) Grasses (d) None of these

8. When stomata are equally distributed on both surfaces of leaf tissue, are:
(a) Potato type (b) Oat type
(c) Apple type (d) Lily type

9. 'Photosynthetic production in guard cells' theory was put forward by:
(a) Scarth (b) Lloyd
(c) Von Mohl (d) Sayre

10. Which ions are responsible for stomatal movement, according to Levitt?
(a) Fe^{2+} (b) Zn^{2+}
(c) K^{+} (d) Na^{+}

11. Scotoactive stomata are found in :
(a) *Aloe* (b) *Salsola*
(c) *Sedum* (d) All of these

12. Maximum opening of stomata occurs at:
(a) 8.00 AM (b) 12.00 Noon
(c) 10.00 AM (d) 4.00 PM

13. On per unit area basis, transpiration rate is more in:
(a) Smaller plants (b) Larger plants
(c) Equal in both (d) Not known

14. Transpiration is maximum in:
(a) Blue light (b) Red light
(c) Far red light (d) Green light

15. Transpiration is a 'necessary evil', called by: **(MPPMT 1999)**
(a) Kozlowski (b) Kramer
(c) Curtis (d) None of these

16. Which of the following is not an antitranspirant?
(a) ABA (b) Aspirin
(c) PMA (d) None of these

17. Transpiration is measured by: **(Orissa JEE 2003)**
(a) Porometer (b) Potometer
(c) Photometer (d) Manometer

18. Guttation occurs through: **(Orissa JEE 2003)**
(a) Lenticels (b) Hydathodes
(c) Stomata (d) Epidermis

19. Guttation is due to: **(CPMT 2000; Uttaranchal PMT 2001)**
(a) O.P. (b) S.P.
(c) Root pressure (d) T.P.

20. Which is wrong regarding guttation?
(a) Loss in liquid form (b) Through hydathodes
(c) Due to root pressure (d) Pure water

21. Guttation occurs when:
(a) Warm days followed by cool nights
(b) Cool days followed by warm nights
(c) Plants growing in dry, warm soil
(d) None of the above

22. The highest loss of water through guttation takes place in:
(a) *Tropaeolum najas* (b) Oat
(c) Barley (d) *Colocasia antiquorum*

23. The stomatal movements are due to:
(a) Pressure of water vapours inside
(b) Turgor pressure of guard cells
(c) Genetic constitution
(d) None of the above

24. Transpiration efficiency refers to:
(a) Water absorption transpiration ratio
(b) Transpiration in relation to ascent of sap
(c) Weight of dry matter produced per kg of water transpired
(d) None of the above

25. When relative humidity of atmosphere is cent per cent, then stomata will:
(a) Open (b) Closed
(c) Partially open (d) Partially closed

*26. Guard cells differ from adjacent epidermal cells in having:
(a) Mitochondria (b) Vacuoles
(c) Cell wall (d) Chloroplasts

27. Stomatal opening is measured by:
(a) Planimeter (b) Potometer
(c) Porometer (d) Photometer

28. The most important factor affecting transpiration is:
(a) Temperature (b) Atmospheric humidity
(c) Wind (d) Light

29. According to Scarth and Sayre, stomatal movement is governed by:
(a) pH (b) Enzymes
(c) Phosphorylation (d) NADH$_2$ formation

30. Site of transpiration is:
(a) Stem (b) Roots
(c) Leaves (d) Aerial parts

31. Which of the following is most likely cause for wider opening of stomata?
(a) The atmosphere outside stoma becomes less humid
(b) Secretion of salt molecules by adjacent cells
(c) Water molecules enter the guard cells
(d) The night temperature falls

32. The stomata open when guard cells are:
(a) Green (b) Flaccid
(c) Large (d) Turgid

33. When fully open, size of stomatal pore is:
(a) $1 - 3\mu \times 5 - 10\mu$ (b) $3 - 12\mu \times 10 - 40\mu$
(c) $1\mu \times 2\mu$ (d) $2\mu \times 4\mu$

34. Significance of transpiration lies in:
(a) Ascent of sap
(b) Absorption and translocation of mineral salts
(c) Cooling effect
(d) All of the above

35. Guttation is .... phenomenon:
(a) Controlled (b) Uncontrolled
(c) Both (a) and (b) (d) Not known

36. 'Plants can grow better in muddy water than in clear rain water', is finding of:
(a) Arnon (b) De Saussure
(c) Woodward (d) None of these

37. Plant ash contains:
(a) Only organic substances
(b) Only minerals
(c) Both (a) and (b)
(d) None of the above

38. Number of essential elements are:
(a) 60 (b) 30
(c) 16 (d) 9

39. The criteria for essentiality of elements was given by:
(a) Woodward (b) Arnon
(c) De Saussure (d) None of these

40. Which is the criterion, on the basis of which, you will determine that particular element is essential?
(a) In its absence, plant is unable to complete its life cycle
(b) Element is specific
(c) It has direct role in metabolism
(d) All of the above

41. Which is a microelement?
(a) N (b) S
(c) Mn (d) Mg

42. Which of the following is not a trace element?
(a) Mn (b) Zn
(c) Cu (d) Ca

43. The usual concentration of oxygen in higher plants (percentage of dry wt) is:
(a) 1.5% (b) 45%
(c) 6% (d) 0.5%

44. Frame work elements are:
(a) C (b) H
(c) O (d) All of these

45. Which of the following is a 'critical element'?
(a) C (b) Mg
(c) K (d) H

46. 'Plastocyanin' (PC) contains:
(a) Mo (b) Mn
(c) Fe (d) Cu

47. Chlorophyll is formed in presence of:
(a) Cu and Fe (b) Mo and Cl
(c) Mg (d) Fe and Mg

48. Iron is used in:
(a) Ferric (Fe^{3+}) form (b) Fe^{2+} form
(c) Galvanized form (d) Not used

49. Which elements are required for photolysis of H$_2$O?
(a) Zn and Mn (b) Mn and Cl
(c) Cl and Mg (d) Fe and Mn

50. Ca is absorbed by plants from soil in the form of:
(a) Its nitrates (b) Sulphates
(c) Both (a) and (b) (d) None of these

51. Nitrogen deficiency causes:
(a) Chlorosis of young leaves
(b) Chlorosis of mature leaves
(c) Both (a) and (b)
(d) None of the above

52. Which element facilitates translocation of sugars in plants?
(a) Zn (b) K
(c) B (d) Mo

53. Which of the following elements is essential for synthesis of IAA?
(a) Fe (b) Zn
(c) B (d) Mn

54. 'Khaira disease of rice' is due to:
(a) Fungus (b) Bacteria
(c) Zn deficiency (d) Mo deficiency

55. Nitrogen fixation is facilitated by:
(a) Cu (b) B
(c) Zn (d) Mo

56. 'Reclamation disease of cereals' and 'whiptail disease of cauliflower' are due to deficiencies of:
(a) Cu (b) Cu and B respectively
(c) Mo and B respectively (d) Cu and Mo respectively

57. Critical elements are:
(a) Which are in more concentration in soil
(b) Which are commonly deficient in soil
(c) Which are absent in soil
(d) None of the above

58. Which zone of root is mainly associated with mineral absorption?

(a) Root hair zone (b) Zone of elongation
(c) Maturation zone (d) Meristematic zone

59. Accumulation of minerals against concentration gradient without expenditure of energy is explained by:
(a) Simple diffusion (b) Carrier concept
(c) Donann's equilibrium (d) None of these

60. Carrier concept of mineral salt absorption was formulated by:
(a) Lundegardh (b) Bennet Clark
(c) Vanden Honert (d) None of these

61. Role of cytochromes is not in:
(a) Respiration (b) Photosynthesis
(c) Salt absorption (d) Transpiration

62. Protein lecithin theory of mineral salt absorption was put forward by :
(a) Lundegardh and Burstrom
(b) Bennet Clark
(c) Vanden Honert
(d) None of the above

63. Translocation of minerals occurs through:
(a) Cortex (b) Phloem
(c) Xylem (d) Pericycle

64. The transfer of minerals from top soil to sub-soil through soil water is called:
(a) Translocation (b) Conduction
(c) Percolation (d) Leaching

65. If chlorophyll is burnt, what element will be left?
(a) Fe (b) Mn
(c) Mg (d) Na

66. Soil less growth is called:
(a) Hygroponics (b) Hydroponics
(c) Zeroponics (d) None of these

67. Minerals to be absorbed by roots are present in form of:
(a) Solids (b) Very dilute solution
(c) Dilute solution (d) Conc. solution

68. Essentiality of a given mineral element can be detected by:
(a) Sand culture (b) Solution culture
(c) Both (a) and (b) (d) None of these

69. Minerals are absorbed by plants:
(a) In colloidal form (b) Ionic form
(c) In precipitated form (d) None of these

70. Leaves can absorb:
(a) Fe (b) Mg
(c) Zn (d) N

71. Cu has mainly:
(a) Balancing function (b) Catalytic function
(c) Toxic effect (d) All of these

72. Which of the following element is not absorbed from soil?
(a) N (b) Fe
(c) B (d) C

73. Sulphur helps in:
(a) Carbohydrate formation
(b) Fat formation
(c) Protein formation
(d) Leaf formation

74. Wilting of leaves in hot weather is due to:
(a) Excessive transpiration
(b) Excess of transpiration as compared to water absorption
(c) Excessive water absorption by roots
(d) Lack of water absorption

75. Guard cells are found in:
(a) Stomata (b) Root tips
(c) Ovary (d) Lenticels

76. The following percentage of water absorbed by herbaceous plants is lost in transpiration:
(a) 80 (b) 60
(c) 99 (d) 40

*77. Which one of the following factors causes an increase in transpiration rate?
(a) A hot dry windy day (b) A cool damp windy day
(c) A hot damp windy day (d) None of these

78. The apparatus generally used for studying the rate of transpiration stream is: **(AFMC 1993; Raj. PMT 2002)**
(a) Potometer (b) Evaporimeter
(c) Atmometer (d) Perimeter

79. Wilting of the plant occurs when: **(Re. Ex. CPMT 1991)**
(a) Xylem is blocked
(b) Phloem is blocked
(c) Both xylem and phloem are blocked
(d) A few roots are removed

80. Guttation is the process of elimination of water from plants through:
(a) Lenticels (b) Wounds
(c) Stomata (d) Hydathodes

81. The guttation is caused due to:
(a) Imbibition (b) Osmosis
(c) Root pressure (d) Transpiration

82. The metal ion involved in the stomatal regulation is: **(Manipal 2001; Uttaranchal 2001)**
(a) Iron (b) Magnesium
(c) Zinc (d) Potassium

83. Which photoreceptor controls the opening and closing of stomata?
(a) Carotene (b) Phytochrome
(c) Chlorophyll-a (d) Chlorophyll-b

*84. At what time the stomatal transpiration in plants is almost completely stopped? **(CPMT 1992)**
(a) Morning (b) Night
(c) Evening (d) None of these

85. Which of the following walls of guard cells are thick?
(a) Outer (b) Inner
(c) Side walls (d) All of these

86. Which of the following plants do not transpire?
(a) Algae (b) Fungi
(c) Submerged hydrophytes (d) All of these

87. Transpiration increases by: **(MPPMT 1993)**
(a) High humidity (b) Wetness in soil
(c) High temperature (d) Low wind velocity

88. Maximum transpiration occurs through: **(Raj. PMT 1992)**
(a) Aerial root (b) Stem
(c) Leaf (d) Fruits

*89. Stomatal pore has wider opening in: **(MDAT Bihar 1991)**
(a) Far red light (b) Blue light
(c) Green light (d) Yellow light

90. Gaseous exchange in submerged hydrophytes takes place through:
(a) Lenticels (b) Stomata
(c) Water stomata (d) General epidermis

*91. If the temperature remains constant the rate of transpiration increases more in:
(a) Plants 1 km below sea level
(b) Plants at sea level
(c) Plants 1 km above sea level
(d) Plants 1.5 km above sea level

92. Which of the following has rapid rate of transpiration? **(DPMT 1990)**
(a) Mesophytes (b) Xerophytes
(c) Parasite (d) Saprophyte

93. Unequal loss of water from two surfaces of a dorsiventral leaf can be determined by:
(a) Cobalt chloride paper (b) Ganong's potometer
(c) Darwin's potometer (d) None of these

94. Which of the following is theory of stomatal opening and closing given by Levitt?
(a) Theory of starch-glucose transformation
(b) Theory of active K^+ transport
(c) Theory of starch-sugar interconversion
(d) None of the above

95. Transpiration would be lowest when:
(a) Wind velocity is high
(b) Enough water is in the soil
(c) Atmospheric R.H. is high
(d) High temperature and light

96. The number of stomata present per cm^2 of leaf is: **(CPMT 1991)**
(a) Less than 100 (b) 1000
(c) One million (d) None of these

97. Which of the following is responsible for passive guttation?
(a) Tension-cohesion of water molecules
(b) Action of epithem tissue
(c) Osmotic activity of root hairs
(d) Secretion of fluid by mesophyll cells

98. Theory of starch-glucose interconversion was proposed by:
(a) Yin and Tung (b) Zelitch
(c) Imamura (d) None of these

99. Which would do maximum harm to a tree?
(a) The loss of half of its leaves
(b) The loss of all of its leaves
(c) The loss of half of its branches
(d) The loss of its bark

100. Wilting of plant results from excessive: **(CPMT 1994)**
(a) Absorption (b) Photosynthesis
(c) Respiration (d) Transpiration

101. The rate of transpiration will greatly depend upon:
(a) Frequency of stomata (b) Position of stomata
(c) State of stomata (d) None of these

102. Which one of the following will reduce the rate of transpiration?
(a) Increase in wind velocity
(b) Rise in temperature
(c) Increase in water uptake by plants
(d) Decrease in light intensity

103. The chief role of transpiration in plants is to cause: **(AFMC 1994)**
(a) Loss of surplus water (b) Cooling of the plant
(c) Rapid ascent of sap (d) Rapid rise of minerals

104. In land plants, guard cells differ from other epidermal cells in having: **(CPMT 1993)**
(a) Nucleus (b) Chloroplast
(c) Mitochondria (d) Endoplasmic reticulum

105. What is the action spectrum of transpiration?
(a) Orange and red (b) Blue and red
(c) Green and ultraviolet (d) Blue and far red

106. The condition under which transpiration would be most rapid is?
(a) Excess of water in soil
(b) Low humidity, high temperature, guard cells are turgid and moist soil
(c) Low velocity of wind
(d) High humidity

107. Transpiration occurs through:
(a) Stomata (b) Cuticle
(c) Lenticels (d) All of these

108. Potometer is used to measure:
(a) Rate of respiration (b) Rate of transpiration
(c) Growth (d) Osmosis

109. The pores in leaves through which water comes out in the form of drops or droplets are called?
(a) Bordered Pits (b) Hydathodes
(c) Stomata (d) Lenticel

110. The actual water vapour content in air is called:
(a) Relative humidity (b) Differential humidity
(c) Absolute humidity (d) Positive humidity

111. Increase in CO_2 concentration around the leaf results in stomatal:
(a) Opening
(b) Partial Closure
(c) Complete closure
(d) No effect on stomatal opening

112. The effective adaptation for better gas exchange in plants is: **(CBSE 1993)**
(a) Large number of hairs on lower epidermis
(b) Presence of stomata on lower surface of leaf
(c) Multiple epidermis
(d) Waxy cuticle

113. Maximum transpiration occurs from: **(AIIMS 1991)**
(a) Dermal tissue
(b) Ground tissue of scale leaves

(c) Periderm and lenticels
(d) Protoderm + procambium

114. Position and frequency of stomata on a leaf can be determined by:
(a) Calculating the loss of water
(b) Cobalt chloride paper method
(c) Photometer method
(d) Porometer method

115. *Potamogeton* possesses:
(a) Functional stomata (b) More functional stomata
(c) Non functional stomata (d) Oat type stomata

116. Under what conditions transpiration would be most rapid?
(a) Excess of water in the soil
(b) Low temperature and high humidity
(c) Bright light and high CO_2
(d) High temperature and low relative humidity

117. Use of antitranspirant may check: **(BHU 1990)**
(a) Transpiration in fruit plants
(b) Transpiration in vegetable plants
(c) Transpiration in crop plants
(d) All of the above

118. Guttation usually occurs in a well watered herbaceous plant and well drained soil only in: **(Raj. PMT 1992)**
(a) Morning hours (b) Evening hours
(c) Noon hours (d) Dry hours

119. Application of phenyl mercuric acetate acts as a:
(a) Weedicide (b) Hormone
(c) Antitranspirant (d) Growth regulator

120. In both transpiration and evaporation, water is lost in the form of vapour yet they differ because: **(CPMT 1992)**
(a) Both transpiration and evaporation are similar but the rate of water loss differs
(b) Frequency of water loss is different in both of them
(c) Transpiration is a physical process and evaporation is a physiological process
(d) Transpiration is a physiological process and evaporation is a physical process

121. Potometer and clinostat are used to study:
(a) Photosynthesis and respiration
(b) Transpiration and growth
(c) Phototropism and geotropism
(d) Transpiration and geotropism

122. Guttation may be defined as a process in which plants can:
(a) Synthesize carbohydrates
(b) Excrete the salt
(c) Get rid of excess water in liquid form
(d) Compensate the loss of water

123. In a terrestrial habitat which of the following factors affect temperature and rainfall conditions?
(a) Translocation (b) Transpiration
(c) Transformation (d) Thermodenaturation

124. Starch-sugar conversion hypothesis of the stomatal opening was proposed by:
(a) Emmerson (b) Sachs
(c) Sayre and Steward (d) Levitt

125. Stomatal closing is affected by:
(a) Kinetic acid (b) Abscisic acid
(c) Gibberellic acid (d) IAA

126. One of the following hypothesis is not related to opening and closing of stomata: **(CPMT 1992)**
(a) Interconversion of starch and sugar
(b) Active potassium ion transport
(c) Kisselbash
(d) Steward

127. What is the most important precaution to be observed in finding out the rate of transpiration through Ganong's potometer?
(a) A broad leaf plant need to be selected
(b) The experimental shoot should be obliquely cut
(c) The shoot should be cut under water
(d) Apparatus to be filled with water

128. In scotoactive opening of stomata, they remain open during:
(a) Day (b) Night
(c) Early morning only (d) Throughout day and night

129. From active hydathodes, the water comes out by: **(BHU 1990)**
(a) Osmotic pressure
(b) Secreted by force developed within cells themselves
(c) By root pressure
(d) None of the above

130. With increase in temperature the rate of transpiration becomes:
(a) Low
(b) High
(c) Low in herbs and high in trees
(d) Immediately stopped

131. Stomatal frequency means:
(a) Number of stomata per unit area of leaf surface
(b) Number of epidermal cells per unit area of leaf surface
(c) Number of mesophyll cells in the per unit area of leaf
(d) None of the above

*132. Guttation only occurs in: **(MDAT Bihar 1991)**
(a) Hydrophytes [✓ (b) Mesophytic herbs]
(c) Mangroves (d) Marshy plants

133. Which process brings about cooling of leaves ? or the shade of a tree is cooler than the shade of a roof due to:
(a) Guttation (b) Green leaves
(c) Transpiration (d) Photosynthesis

134. The ultimate force which propels water against the gravity is generated by:
(a) Osmosis (b) Imbibition
(c) Transpiration (d) ATP–hydrolysis

135. Passive absorption of water by the root of a plant is affected by:
(a) Anatomy of root
(b) D.P.D. of root hairs
(c) Transpirational tension
(d) Osmotic concentration of root hairs

136. Which one of the following chemicals serves as an antitranspirant in plants? **(MPPMT 1995)**
(a) Cobalt chloride (b) Mercury
(c) Potassium (d) Phenylmercuric acetate

137. Stomata open due to: **(CPMT 1994)**
(a) Light intensity
(b) Presence of CO_2
(c) Influx of K^+ in the guard cells
(d) Photosynthesis in guard cells

138. Which of the following process causes rapid absorption of water and nutrients by a plant? **(Raj. PMT 1990)**
(a) Diffusion/Imbibition
(b) Osmosis
(c) Active absorption
(d) Transpiration/Passive absorption

139. Process of water exudation through hydathodes is called: **(BHU 1995, 2000)**
(a) Guttation (b) Transpiration
(c) Excretion (d) Hydrolysis

140. Potassium ion exchange hypothesis to explain the opening and closing of stomata was proposed by: **(BHU 1994)**
(a) Manners (b) Levitt
(c) Stewards (d) Sayre

141. Which of the following is used for determining the rate of transpiration in plants? **(CBSE 1994; AIIMS 2000)**
(a) Porometer (b) Potometer
(c) Tensiometer (d) Auxanometer

142. Cooling of atmosphere is by the process of: **(MDAT Bihar 1995)**
(a) Photosynthesis (b) Transpiration
(c) Photorespiration (d) Assimilation

143. Which of the following statement is correct?
(a) Water and salts are taken in simultaneously by root hairs
(b) Plants absorb one thing at a time either water or inorganic salt
(c) Plants absorb excess quantity of water
(d) Plants take in small quantity of water

*144. Maximum transpiration occurs in: **(MPPMT 1994)**
(a) Mesophytic plants (b) Hydrophytic plants
(c) Xerophytic plants (d) Algal cells

145. Presence of thick cuticle, hairs, scales and fewer sunken stomata are found in the leaves of xerophytes, it is to:
(a) Stop transpiration
(b) Facilitate transpiration
(c) Store water
(d) Check excessive transpiration

*146. Which of the process is responsible for loss of sugars and salts from plants?
(a) Transpiration (b) Guttation
(c) Both (a) and (b) (d) None of these

147. When strips of cobalt chloride papers are placed on either side of a dorsiventral leaf, why the strips on the lower side become speedily pink?
(a) More CO_2 is evolved from the lower side
(b) More O_2 is evolved from the lower side
(c) More H_2O is lost from the lower side
(d) All of the above

148. Which of the following methods may be used to determine the quantitative loss of water from two surfaces of a dorsiventral leaf?
(a) Cobalt chloride paper method
(b) Four leaf experiment
(c) Double bell jar method
(d) None of the above

149. One of the leaf of a potted plant 'A' is vaselined on its upper side and another leaf 'B' on its lower side, what would be the response on their wilting?
(a) 'A' wilts faster than 'B'
(b) 'B' wilts faster than 'A'
(c) Both wilts equally
(d) Neither of the two wilts

150. Transpiration is most rapid in:
(a) Humid atmosphere and moist soil
(b) Moist soil, dry air and windy day
(c) Dry soil, dry air and absence of wind
(d) None of the above

151. Which of the following is an adaptation to reduce water loss? **(EAMCET 1991)**
(a) Presence of thick cuticle
(b) Change of leaf into spine
(c) Change of leaf into phylloclade
(d) All of the above

*152. Principle of working of all potometers is: **(Raj. PMT 1990)**
(a) Absorption occurs by stem
(b) Absorption is a physical process
(c) Absorption is proportional to transpiration
(d) Transpiration depends on light

153. The cause of permanent wilting is:
(a) Rapid translocation
(b) Rapid transpiration
(c) Poor availability of soil water
(d) Deficiency of nutrients

154. Stomatal closure in response to leaf stress is mediated by: **(BHU 1993)**
(a) IAA (b) IBA
(c) ABA (d) 2, 4-D

155. Stomata open during day because the guard cells have: **(MPPMT 1993)**
(a) Outer wall thin (b) Kidney shape
(c) Chlorophyll (d) Large nuclei

156. The process of the escape of liquid from the tip of injured leaf is called: **(CPMT 1990)**
(a) Evaporation (b) Transpiration
(c) Guttation (d) Evapo-transpiration

157. Stomata in angiosperms open and close due to:
(a) Their genetic constitution
(b) Effect of hormones

(c) Changes of turgor pressure in guard cells
(d) Pressure of gases inside the leaves

158. Which of the following method of water absorption is affected by opening and closing of stomata?
(a) Passive (b) Active
(c) Both (a) and (b) (d) None of these

*159. Stomata open at night and close during the day time in:
(a) Succulents (b) Mesophytes
(c) Hydrophytes (d) Xerophytes

160. Due to low atmospheric pressure the rate of transpiration will:
(a) Decrease slowly (b) Decrease rapidly
(c) Increase (d) Remain unaffected

161. Under what conditions the transpiration rate will be maximum?
(a) Soil is wet and atmosphere is dry
(b) Soil is dry and atmosphere is humid
(c) Soil is wet and atmosphere is humid
(d) Soil is dry and atmosphere is dry

162. Out of the following which one is the most common type of transpiration?
(a) Foliar (b) Stomatal
(c) Lenticular (d) Cuticular

163. The loss of water in the form of vapour from aerial parts is known as: (AFMC 1993)
(a) Osmosis (b) Respiration
(c) Photosynthesis (d) Transpiration

164. In which of the following plants would metabolism be hindered if the leaves are coated with wax on their upper surface?
(a) *Vallisnaria* (b) *Pistia*
(c) Lotus (d) *Hydrilla*

165. Active K^+ exchange mechanism for opening and closing of stomata was given by: (BHU 1997)
(a) Deblin (b) Levitt
(c) Khorana (d) Heath

166. Transpiration is minimized by the deposition of:
(a) Cellulose (b) Pectin
(c) Cutin (d) Mucilage

167. Guttation usually occurs when the plant is put:
(a) In a more saturated atmosphere
(b) In more humid soil
(c) In dry condition
(d) In deserts

168. Phenylmercuric acetate:
(a) Reduces transpiration
(b) Reduces photosynthesis
(c) Reduces respiration rate
(d) Kills the plant

169. Ultimate cause of water movement against gravity is:
(a) Osmosis (b) Imbibition
(c) Photosynthesis (d) Transpiration

170. Transpiration helps the plant chiefly by: (CPMT 1993)
(a) Facilitating movement of water
(b) Cooling
(c) Loosening excess of water
(d) Preventing water logging condition in soil

171. The transpiration in plants will be lowest:
(a) When there is high humidity in the atmosphere
(b) Because of high wind velocity
(c) When there is excess of water in the cells
(d) When environmental conditions are very dry

172. Two chief functions of leaves are:
(a) Transpiration and respiration
(b) Respiration and digestion
(c) Photosynthesis and respiration
(d) Photosynthesis and transpiration

173. A well watered herbaceous plant exhibits a decrease in rate of transpiration in intense light, this is due to:
(a) High rate of photosynthesis
(b) Partial closure of stomata
(c) Photo-oxidation of chlorophyll
(d) Loss of water from the soil

174. Which of the following is produced during water stress and causes closure of stomata? (BHU 1991)
(a) Cytokinin (b) Auxin
(c) GA_3 (d) ABA

175. Conversion of starch to organic acid is essential for: (CBSE 1992)
(a) Stomatal closure (b) Stomatal opening
(c) Stomatal initiation (d) Stomatal growth

176. The stomata will open if there is an accumulation of the following element in its guard cells: (MPPMT 1990)
(a) Mg (b) K
(c) Fe (d) Ca

*177. In most of the thin leaf mesophytes, the leaf stomata open during day and close during night. It comes under: (CPMT 1991)
(a) Barley type (b) Potato type
(c) Alfalfa type (d) Bean type

178. In guard cells when sugar is converted into starch, the stomatal pore: (CBSE 1992)
(a) Opens partially (b) Opens completely
(c) Closes completely (d) Remains unchanged

179. Transpiration from plants would be most rapid when:
(a) Environmental conditions are dry
(b) There is lot of humidity in atmosphere
(c) The air is still
(d) There is excess of water in sky

180. Process of transpiration in plants helps in:
(a) Absorption of CO_2 (b) Upward conduction
(c) Opening of stomata (d) None of these

181. Increase in temperature and velocity of wind cause an increase in transpiration initially but later it slows down because:
(a) Of closure of stomata
(b) Water is not made available
(c) The air around the plant becomes humid
(d) Mechanical disturbances

182. In succulent plants the stomata open in night and close by day, which of the following would be best hypothesis to explain the mechanism of stomatal action in night only?
(a) CO_2 used up, increased pH results in accumulation of sugars
(b) CO_2 accumulates, reduces pH, stimulates enzymes resulting in accumulation of sugars
(c) Increase in CO_2 conc., conversion of organic acids into starch resulting in the increased uptake of potassium ions and water
(d) Low CO_2 conc., accumulation of organic acids resulting in the increased conc. of cell sap

183. Stomata open during day time because the guard cells:
(a) Photosynthesize and produce osmotically active sugars
(b) Are thin-walled
(c) Are bean shaped
(d) Have to help in gas exchange

184. The transpiration is regulated by the movement of:
(a) Subsidiary cells of the leaves
(b) Guard cells of the stomata
(c) Mesophyll tissue cells
(d) Epidermal cells of the leaves

***185.** Which factor regulates the loss of water through transpiration?
(a) Level of oxygen in air
(b) Nitrogen of the atmosphere
(c) CO_2 of the atmosphere
(d) None of the above

186. Basis of stomatal opening is:
(a) Decrease in cell sap concentration
(b) Plasmolysis of guard cells
(c) Endosmosis
(d) Exosmosis

187. In hot summer day, plant cooling is due to: **(BHU 1991)**
(a) Loss of water vapours from leaf
(b) Transport of water in plant
(c) Loss of liquid water
(d) Loss of water from entire plant

188. In the mechanism of opening of stomata, the important factor is the:
(a) Shape of the guard cells
(b) Chlorophyll content of the cells
(c) Hormone content of the cells
(d) Protein content of the cells

189. Transpiration occurs from:
(a) Stems (b) Roots
(c) Leaves (d) All aerial parts

190. Which of the following changes in the cell sap of the guard cells is responsible for keeping the stomata open during day time?
(a) Decrease in osmotic pressure but increase in turgor pressure
(b) Increase in osmotic pressure but decrease in turgor pressure
(c) Increase of both osmotic and turgor pressure
(d) Decrease of both osmotic and turgor pressure

191. Stomata open because of:
(a) Oxygen in the air
(b) Increased turgidity of the guard cells brought about by exposure to light
(c) Vacuoles in guard cells
(d) All of the above

192. When an oak leaf stoma is opening more widely, the most likely process involved is:
(a) Water molecules are entering the adjacent guard cells
(b) Auxins are accumulating in the guard cells
(c) The atmosphere outside the stoma is becoming less humid
(d) Salt molecules are being excreted by the adjacent guard cells

***193.** Nobel Prize of 1991 for discovering the single ion channels in cell was awarded to: **(EAMCET 1990)**
(a) Erwin Nehar and Bert Sakmann
(b) Holley and Matthaei
(c) Watson and H.G. Khorana
(d) Nirenberg and Kornberg

194. The rate of transpiration directly depends on: **(MPPMT 1990)**
(a) Vapour pressure gradient
(b) Negative turgor pressure and light
(c) Diffusion pressure deficit
(d) Temperature of the atmosphere

195. Which one is an inorganic nutrient?
(a) Protein (b) Calcium
(c) Cellulose (d) Vitamin

196. Mg or Fe are needed by plants for:
(a) Synthesis of chlorophyll
(b) Energy transfer
(c) Translocation of carbohydrates
(d) Stomatal opening

197. Which of the following is not a macronutrient?
(a) Manganese (b) Phosphorus
(c) Calcium (d) Sulphur

198. Chlorosis in plants occurs due to:
(a) Absorption of yellowish pigment from the soil
(b) High sunlight intensity
(c) Deficiency of Mg and Fe in the soil
(d) Low sunlight intensity

199. An essential element is one which:
(a) Is available in soil
(b) Improves plant growth
(c) Is indispensable and irreplaceble for growth
(d) Is present in plant ash

200. Mineral nutrients absorbed by roots, move to leaves through:
(a) Xylem (b) Phloem
(c) Sieve tube (d) Companion cell

201. Non essential element for the proper growth of plant is:
(a) Cobalt (b) Magnesium
(c) Chlorine (d) Calcium

202. Rapid deterioration of root and shoot tip occurs due to the deficiency of:
(a) Calcium (b) Phosphorus
(c) Nitrogen (d) Carbon

203. Which of the following is an important limiting factor for nitrification in the soil?
(a) Temperature (b) Light
(c) Soil reaction (pH) (d) Moisture

***204.** EDTA is much used in tissue cultures, it is a:
(a) Hormone (b) Vitamin
(c) Buffer (d) Nutrient

205. Plants requiring two metabolic compounds (minerals) for chlorophyll synthesis, are:
(a) Fe and Ca (b) Fe and Mg
(c) Cu and Ca (d) Ca and K

206. Deficiency of Mo causes:
(a) Yellowing of leaves
(b) Mottling and necrosis of leaves
(c) Poor development of vasculature
(d) Bending of leaf tip

207. Active transport from outside to inside of molecules across a membrane requires:
(a) Cyclic AMP (b) Acetyl choline
(c) ATP (d) Phloroglucinol

208. A trace element is:
(a) That which draws other elements out of protoplasm
(b) Radioactive and can be traced by Geiger counter
(c) Required in very minute amounts
(d) That which was first found in protoplasm

209. Function of zinc is: **(MPPMT 1992)**
(a) Synthesis of chlorophyll
(b) Biosynthesis of 3–IAA
(c) Closing of stomata
(d) Oxidation of carbohydrate

210. Slow rate of absorption of ion at high temperature is due to:
(a) Low photosynthetic rate
(b) Low rate of transpiration
(c) Enzyme inactivation
(d) All of the above

211. Deficiency of iron causes:
(a) Decrease in protein synthesis
(b) Reduced leaves and stunted growth
(c) Interveinal chlorosis first on young leaves
(d) Bending of leaf tip

212. Which one of the following elements is not required by plants for their normal healthy growth?
(a) Magnesium (b) Lead
(c) Iron (d) Calcium

213. Minerals are absorbed by a plant from the soil by a process:
(a) Independent of water absorption
(b) Dependent on water absorption
(c) Dependent on strength of solutions
(d) Dependent on osmosis

214. Which of the following is a macronutrient?
(a) Mo (b) Ca
(c) Zn (d) Mn

215. Yellowing and premature fall of the leaves is due to the deficiency of:
(a) Ca (b) S or Mg
(c) P or K (d) N

216. Which of the following elements has not been proved to be essential for plants?
(a) Potassium (b) Sodium
(c) Zinc (d) Iron

217. One of the following is needed in the reduction of nitrate to nitrite:
(a) Zn (b) Mo
(c) Fe (d) B

218. The element which is required in largest quantities by plant is:
(a) Nitrogen (b) Calcium
(c) Sulphur (d) Phosphorus

219. The number of essential elements required for normal growth of plant is:
(a) 10 (b) 16
(c) 20 (d) 25

220. One of the following is micronutrient for plants: **(CPMT 1994)**
(a) Nitrogen (b) Manganese
(c) Phosphorus (d) Calcium

221. Why do freshly exposed surfaces of many fruits and vegetables become dark? Because:
(a) Dust from the atmosphere settles on them
(b) Dirty knife leaves some traces of iron on them
(c) Oxidation of tannic acid in the presence of the trace of iron from the knife makes them dark
(d) The fruits are black in colour

222. Which of the following are trace elements? **(DPMT 1990)**
(a) Boron and Manganese
(b) Copper, zinc and iron
(c) Chlorine and Molybdenum
(d) All of the above

223. Carbon becomes available to crop plants in the form of:
(a) Carbon dioxide (b) Element carbon (coal)
(c) Amino acids (d) Carbonates

224. Fertility of the soil in rice fields can be improved by:
(a) Gypsum (b) Sodium chloride
(c) Blue green algae (d) *Rhizobium*

225. Most plants obtain their nitrogen from the soil in the form of:
(a) HNO_3 (b) Nitrate
(c) Free nitrogen gas (d) Nitrogen oxide

226. Which one of the following nutrient serves as microelements for plant growth? **(MPPMT 1995)**
(a) Manganese, copper, calcium
(b) Sodium, potassium, boron
(c) Sodium, nickel, chlorine
(d) Copper, molybdenum, zinc

227. Which one of the following is not a trace element? **(CPMT 1992)**
(a) Cu (b) Zn
(c) Mg (d) Fe

228. Which of the following essential elements do terrestrial plants take exclusively from the air?
(a) Nitrogen (b) Phosphorus
(c) Potassium (d) Carbon

229. Which of the following is a trace element? **(MPPMT 1990)**
(a) Phosphorus (b) Nitrogen
(c) Potassium (d) Zinc

230. Conduction of inorganic materials in plants occur mainly through minerals absorbed by roots move to the leaf through:
(a) Xylem (b) Phloem
(c) Sieve tube (d) None of these

231. Phosphorus works as carrier of:
(a) Cobalt (b) Zinc
(c) Magnesium (d) Copper

232. Element which maintains the solubility of calcium in the cells is:
(a) Manganese (b) Copper
(c) Iron (d) Boron

233. A trace element essential for plant growth and radio-isotope, which is used in cancer therapy is known as:
(a) Calcium (b) Cobalt
(c) Sodium (d) Iron

234. Calcium is present in form of: **(MDAT Bihar 1990)**
(a) Calcium acetate (b) Calcium oxalate
(c) Calcium pectate (d) Calcium carbonate

235. Important contribution of molybdenum is: **(MPPMT 1992; JIPMER 2002)**
(a) Flower growth
(b) Nitrogen fixation
(c) Chromosome condensation
(d) Carbon fixation

236. The theory which suggests that the CO_2 produced in respiration plays an important role in mineral absorption is:
(a) Contact exchange theory
(b) Carbonic acid exchange theory
(c) Active absorption theory
(d) None of the above

237. Which of the following is a micronutrient?
(a) Calcium (b) Phosphorus
(c) Copper (d) Magnesium

238. Cytochrome oxidase contains:
(a) Mg (b) Fe
(c) Hg (d) Co

239. Which is a micronutrient?
(a) Ca (b) Zn
(c) P (d) Mg

240. All the following contributes to the availability of nitrogen compounds in the soil except:
(a) Thunders from clouds
(b) Bacterial decay of animal refuge
(c) *Azotobacter*
(d) Addition of lime

241. Micronutrients:
(a) Are as important as macronutrients
(b) Are less important than macronutrients
(c) Are called 'micro' as they play only a minor role in plant nutrition
(d) May be omitted from culture media without any detrimental effect on the plants

242. In hydrophytic plants, water and salts are absorbed by : **(MPPMT 1992)**
(a) Roots (b) Leaves
(c) Stem (d) Outer layer of plants

243. Which is not an essential micronutrient?
(a) Ni (b) Cu
(c) Mn (d) B

244. Chlorosis of plants is caused by the deficiency of: **(MPPMT 1995)**
(a) Iron (b) Boron
(c) Copper (d) Calcium

245. Which of the following is not a micronutrient? **(CPMT 1993)**
(a) Mo (b) Cu
(c) Zn (d) P

246. Which one of the following is a micronutrient? **(CPMT 1991)**
(a) Mg (b) Ca
(c) Mn (d) S

***247.** Of the following amino acids which one is sulphur containing one?
(a) Aspargine (b) Proline
(c) Serine (d) Methionine

248. Death of stem and root tips occur due to deficiency of:
(a) Phosphorus (b) Calcium
(c) Nitrogen (d) Carbon

249. Which of the following is not a part of enzyme but it activates the enzyme?
(a) K- (b) Zn
(c) Mg (d) Mn

250. Which one of the following elements is present in chlorophylls? **(MPPMT 1995)**
(a) Manganese (b) Magnesium
(c) Copper (d) Iron

251. Presence of phosphorus in a plant: **(CPMT 1991)**
(a) Brings about healthy root growth
(b) Promotes fruit ripening
(c) Retards protein formation
(d) None of the above

252. Which of the following element is not necessary for growth? **(CPMT 1993)**
(a) Carbon (b) Nitrogen
(c) Sodium (d) Potassium

*253. The plant ash is an indication of: (CPMT 1990)
(a) Mineral salts absorbed by the plant
(b) Organic matter of the plant
(c) Both the mineral salts and organic matter
(d) None of the above

254. Which of the following is required for binding protein with nucleic acid?
(a) Nickel (b) Iron
(c) Cobalt (d) Calcium

255. The micronutrient among the following is: (Re. Ex. CPMT 1991)
(a) N (b) P
(c) Zn (d) Ca

256. The four elements that make up 99% of all elements found in a living system are:
(a) H, O, C, N (b) C, H, O, S
(c) C, H, O, P (d) C, N, O, P

257. Which of the following is trace element? (BHU 1991)
(a) Carbon (b) Phosphorus
(c) Sulphur (d) Molybdenum

258. For the growth of which of the following sodium is required?
(a) *Lycopersicum esculentum*
(b) *Ziziphus*
(c) *Nigella sativa*
(d) *Atriplex*

259. Functions and vital activities of the plants are studied under:
(a) Ecology (b) Cytology
(c) Physiology (d) Morphology

260. An important essential element is necessary in plants for protein synthesis: (MPPMT 1991)
(a) Calcium (b) Phosphorus
(c) Magnesium (d) Nitrogen

261. The role of molybdenum is:
(a) Chromosome contraction
(b) Carbon assimilation
(c) Nitrogen fixation
(d) Flowering induction

262. The non-essential element of the plant is:
(a) Barium (b) Magnesium
(c) Potassium (d) Calcium

263. Chlorosis occurs in plants grown in:
(a) Shade (b) Fe-free medium
(c) Dark (d) Strong light

264. Hydroponics is a method of: (MPPMT 1992)
(a) Study of the development of soil
(b) Study of soil protection
(c) Growth of plants in liquid culture medium
(d) Growing plants in laboratory

265. Absence of Mg^{2+} ions from plant tissue results in: (CPMT 1991)
(a) Plasmolysis (b) Hydrolysis
(c) Chlorosis (d) Necrosis

266. Essential macroelements are: (MPPMT 1993)
(a) Absorbed from soil
(b) Manufactured during photosynthesis
(c) Produced by enzymes
(d) Produced by growth hormones

267. Which of the following amino acid is non-sulphur containing?
(a) Cystein (b) Glycine
(c) Cystine (d) Methionine

268. In ash analysis experiment, the plant material is strongly heated in presence of oxygen, the resulting residue is having carbonates and oxides of:
(a) 4 elements (b) 10 elements
(c) 16 elements (d) None of these

269. A red pigment 'leghaemoglobin' in root nodules of legumes is helpful in nitrogen fixation by:
(a) Providing oxygen
(b) Helping in aerobic respiration
(c) By removal of oxygen
(d) None of the above

270. Excessive supply of nitrogen to plants results in:
(a) Large number of dark green leaves
(b) Lesser number of variegated leaves
(c) No leaves
(d) Yellowish leaves

271. The mineral required for phosphorylation reactions is:
(a) Nitrogen (b) Zinc
(c) Magnesium (d) Phosphorus

272. The minerals necessary for animals but not required by most of the plants are:
(a) Na and I (b) K and I
(c) K and Cl (d) Na and Cl

*273. 'Hunger signs' in plants are:
(a) Symptoms due to lesser water absorption in plants
(b) Symptoms due to poor photosynthesis in plants
(c) Deficiency symptoms of particular mineral nutrients
(d) None of the above

274. 'Turgor operated valves' in plants are:
(a) Lenticels (b) Hydathodes
(c) Stomata (d) Cyphallae

*275. ABA is commonly called stress hormone, because:
(a) It causes water stress in high light intensity
(b) It prevents excessive loss of water
(c) It causes defoliation in water stress conditions
(d) All of the above

276. Which one is not related to transpiration? (MPPMT 1997)
(a) Regulation of plant body temperature.
(b) Absorption and distribution of mineral salts
(c) Circulation of water
(d) Bleeding

277. A small mesophytic twig with green leaves is dipped into water in a beaker under sunlight. It demonstrates: (MPPMT 1997)
(a) Photosynthesis (b) Respiration
(c) Transpiration (d) None of these

278. In absence of essential mineral elements, leaves of many plants turn yellow due to:
(a) Plasmolysis (b) Chlorosis
(c) Necrosis (d) Etiolation

279. During its growing season, a corn (maize) plant can transpire water:
(a) 1 gallon (b) 5 gallons
(c) 10 gallons (d) 50 gallons

280. Presence of trichomes (hairs) on leaves:
(a) Helps in rapid gaseous exchange
(b) Increases transpiration
(c) Reduces transpiration
(d) Prevents guttation

281. 'Brown Heart' disease is caused by deficiency of: **(BHU 1992)**
(a) K (b) Mo
(c) B (d) Fe

282. The phytohormone which is supposed to be one of the factor responsible for regulating the opening and closing stomata is? **(Pondicherry 1996; Manipal 1997)**
(a) ABA (b) IBA
(c) GA (d) Kinetin

283. The essential element for the synthesis of auxin is: **(Pb. PMT 1997)**
(a) Zinc (b) Potassium
(c) Sulphur (d) Phosphorus

284. The role of inorganic nutrients in plant growth was at first indicated by: **(Pondicherry 1996; Manipal 1997)**
(a) Woodward (b) Stewart
(c) De Saussure (d) Knop

285. The loss of water through cuticle may reach upto: **(AMU 1997)**
(a) 5% (b) 20%
(c) 10% (d) 40%

286. The most important element associated with protoplasm and proteinaceous material of plant is: **(AMU 1996; Pb. PMT 1997)**
(a) Oxygen (b) Sulphur
(c) Potassium (d) Nitrogen

287. The essential nutrient element required by plants in the least quantity is: **(AMU 1994, 97)**
(a) Chlorine (b) Molybdenum
(c) Manganese (d) Zinc

288. Which one is not related to transpiration? **(AMU 1997)**
(a) Regulation of plant body temperature
(b) Absorption and distribution of mineral salts
(c) Circulation of water
(d) Bleeding

*289. Enzyme catalyzed reactions can be inhibited by: **(AMU 1997)**
(a) Zn^{2+} (b) Mg^{2+}
(c) Hg^{2+} (d) Cu^{2+}

290. Permeability of protoplasm is accelerated by: **(AMU 1997)**
(a) K (b) Na
(c) Ca (d) P

291. Which one of the following factors is most important in regulation of transpiration? **(Manipal 1997; CET Chandigarh 1997; CET J & K 2002)**
(a) Light (b) Wind
(c) Temperature (d) Humidity

292. In fruit trees a disease 'exanthema' is caused by the deficiency of: **(AMU 1997)**
(a) Na (b) Ca
(c) Cu (d) P

293. The movement of mineral ions into plant root cells as a result of diffusion is called: **(CBSE 1996; CET Chandigarh 1997)**
(a) Osmosis (b) Passive absorption
(c) Active absorption (d) Endocytosis

294. A twig kept in water remains fresh for a longer time if some salt is added to it, it is due to:
(a) Exosmosis
(b) Decrease in transpiration rate
(c) Absorption of more water
(d) Decrease in bacteroid degradation activity

295. In nature, organic compounds invariably contain: **(APPMT 1996)**
(a) Carbon (b) Phosphorus
(c) Sulphur (d) Magnesium

296. Bidirectional translocation of minerals takes place in: **(CBSE 1997)**
(a) Xylem (b) Phloem
(c) Parenchyma (d) Cambium

297. Which element is largely responsible for maintaining turgor in plants? **(BHU 1996)**
(a) Na (b) Ca
(c) Hg (d) K

298. The brown colour of leaves of cabbage is due to the deficiency of: **(BHU 1997)**
(a) Boron (b) Calcium
(c) Nitrogen (d) Sulphur

299. Fall of immature leaf is due to the deficiency of:
(a) Sulphur (b) Phosphorus
(c) Sodium (d) Zinc

300. Loss of water from the tips of leaves is called as: **(AFMC 1998)**
(a) Guttation (b) Transpiration
(c) Respiration (d) Bleeding

301. Modern theory of stomatal opening is: **(CPMT 1998; BCECE 2002)**
(a) K^+ exchange (b) Sugar transport
(c) Acid transport (d) Water osmosis

302. Plant growth without soil is called: **(CPMT 1998)**
(a) Hydroponics (b) Heterosis
(c) Culture (d) Auxotroph

303. Which is not a macroelement? **(CPMT 1999)**
(a) Calcium (b) Nitrogen
(c) Potassium (d) Zinc

304. Phenyl mercuric acetate acts as: (CPMT 1999)
(a) Transpiration inhibitor (b) Respiration inhibitor
(c) Photosynthesis inhibitor (d) All of these

305. Trace elements are: (BHU 1999)
(a) Radioactive and counted by G.M. counter
(b) Elements present in low concentration and required for healthy growth
(c) Radioactive elements in small quantity
(d) None of the above

*306. Stomata can also open at night in: (MPPMT 1999)
(a) Xerophyte (b) Gametophyte
(c) Hydrophyte (d) None of these

307. Cultivation by sand culture is also called:
(a) Soilless cultivation (b) Green house effect
(c) Photorespiration (d) None of these

308. Inorganic nutrients are present in the soil in the form of: (MPPMT 1999)
(a) Molecules.
(b) Atoms
(c) Electrically charged ions
(d) Parasite

309. Zinc is used up by plants in the form of: (CBSE 2000)
(a) Zn (b) Zn^{2+}
(c) $ZnSO_4$ (d) $Zn(NO_3)_2$

310. Mg is important constituent of: (CBSE 2000)
(a) Chlorophyll (b) Haemoglobin
(c) Cytochrome (d) None of these

*311. Which of the following elements are used up in phosphorylation? (AFMC 2000)
(a) N and P (b) I and P
(c) Ca and Mg (d) Ca and S

312. Which of the following will reduce the rate of transpiration? (MPPMT 2000)
(a) Increase in wind velocity
(b) Rise in temperature
(c) Decrease in light intensity
(d) Increase in water uptake by plants

313. Match the names of activities listed under column-I with the description of activity given under column-II; choose the answer which gives the correct combination of the alphabets of the two columns: (CET Karnataka 2000)

S. No.	Column-I (Activities)		Column-II (Description of activity)
A	Transpiration	p	Anaerobic respiration in yeast
B	Guttation	q	Active absorption of water
C	Exudation	r	Loss of water vapour from plant parts
D	Fermentation	s	Loss of liquid water from leaves
		t	Loss of water from injured plant parts

(a) A = p, B = t, C = s, D = r
(b) A = q, B = r, C = s, D = t
(c) A = s, B = r, C = p, D = t
(d) A = r, B = s, C = t, D = p

314. Wilting in plants occurs due to increase in: (AFMC 2001)
(a) Photosynthesis (b) Photoperiodism
(c) Transpiration (d) Osmosis

*315. Glycolate induces opening of stomata in: (CBSE 2001)
(a) Presence of O_2 (b) Low CO_2 concentration
(c) High CO_2 (d) CO_2 absent

316. Match the names of the experiments listed under column-I with the aim of the experiment given under column-II; choose the answer which gives the correct combination of the alphabets:

S. No.	Column-I (Experiment)		Column-II (Aim)
A	Girdling experiment	p	Ascent of sap
B	Cobalt chloride paper method	q	Transpiration
C	Cresograph	r	Unequal transpiration of leaf surfaces
D	Belljar experiment	s	Translocation in phloem

(CET Karnataka 2001)

(a) A = r, B = p, C = s, D = q
(b) A = s, B = r, C = p, D = q
(c) A = s, B = p, C = q, D = r
(d) A = q, B = p, C = s, D = r

317. Maximum transpiration occurs from: (BHU 2000)
(a) Protoderm and procambium
(b) Dermal tissue
(c) Periderm and lenticels
(d) Ground tissue of scale leaves

318. Which of the following theories gives the latest explanation for closure of stomata? (BHU 2001)
(a) ABA theory (b) Munch theory
(c) Starch glucose theory (d) Active K^+ transport theory

319. Guttation is the direct evidence for the presence of : (BHU 2001)
(a) Tension (b) Root pressure
(c) Turgor pressure (d) Water potential

320. Those fertilizers, which provide all the essential elements such as N, P and K, etc. required for plant growth, are called: (BHU 2001)
(a) Direct fertilizers (b) Indirect fertilizers
(c) Complete fertilizers (d) Incomplete fertilizers

321. In which of the following the rate of transpiration is high? (MPPMT 2001)
(a) CAM plants (b) C_3 plants
(c) C_3 and C_4 plants (d) C_4

322. Turgidity in guard cells is controlled by: (MPPMT 2001)
(a) Chloride
(b) Malic acid
(c) Potassium
(d) Potassium, chloride and malic acid

*323. The amount of water lost by plants in the form of vapour is: **(JIPMER-2002)**
(a) 10% (b) 50%
(c) 80% (d) 90%

324. Water lost by transpiration is : **(CET Karnataka 2002)**
(a) Rich in solutes (b) Rich in dissolved minerals
(c) Rich in dissolved salts (d) Pure water

325. A common feature shared by guard cells and mesophyll cells is: **(CET Karnataka 2002)**
(a) Dumb-bell shaped structure
(b) Presence of chloroplasts
(c) Uniformly thin cell wall
(d) Differentially thick cell wall

326. Which of the following plant hormones reduces transpiration rate by inducing stomatal closure? **(BHU 2002)**
(a) ABA (b) Ethylene
(c) Cytokinin (d) Gibberellin

327. The rate of transpiration in plants is dependant upon: **(AFMC 2002)**
(a) Temperature and soil
(b) Light and temperature
(c) Wind, temperature and light
(d) Light, temperature, atmospheric humidity and wind

328. Which of the following minerals helps in N_2-fixation? **(AFMC 2002)**
(a) Copper (b) Zinc
(c) Molybdenum (d) Magnesium

329. Opening and closing of stomata is due to: **(CBSE 2002)**
(a) Hormonal change in guard cells
(b) Change in turgor pressure of guard cells
(c) Gaseous exchange
(d) Respiration

330. Nitrogen is essential component of: **(MPPMT 2002)**
(a) Carbohydrates (b) Fats
(c) Proteins (d) Oils

331. Active transport of ions by the cell requires: **(MPPMT 2002)**
(a) High temperature (b) ATP
(c) Alkaline pH (d) Salts

332. Tracer elements are: **(MPPMT 2002)**
(a) Microelements (b) Macroelements
(c) Radioisotopes (d) Vitamins

333. The microelement required for the synthesis of IAA is represented in its ionic form as a cofactor in this enzyme: **(EAMCET 2002)**
(a) Catalase (b) PEP-Carboxykinase
(c) Carbonic anhydrase (d) Nitrogenase

334. Mostly plants absorb nitrogen from the soil in the form of: **(Orissa JEE 2002)**
(a) Ammonium ion (b) Dinitrogen
(c) Nitrite (d) Nitrate

335. Humidity in atmosphere decreases rate of: **(CPMT 2003)**
(a) Transpiration (b) Photosynthesis
(c) Glycolysis (d) Growth

336. The set of three elements included fully in micronutrients is: **(Orissa JEE 2003)**
(a) Na, Cu, Mg (b) Fe, Zn, Cu
(c) Fe, K, Ca (d) Mn, O, P

337. Which of the following deficiency may cause leaf tip bending? **(BV Pune 2003)**
(a) Calcium (b) Phosphorus
(c) Nitrogen (d) Sulphur

338. Which of the following is not a controlled process? **(BV Pune 2003)**
(a) Guttation (b) Transpiration
(c) Both (a) and (b) (d) None of these

339. Grey spots of oat are caused by the deficiency of: **(CBSE 2003)**
(a) Zn (b) Mn
(c) Fe (d) Cu

340. Boron in green plants assists in: **(CBSE 2003)**
(a) Photosynthesis (b) Sugar transport
(c) Activation of enzymes (d) Acting as enzyme cofactor

341. Which of the following plants keeps its stomata open during night and closed during the day? **(Orissa JEE 2003)**
(a) Wheat (b) Orchid
(c) Tea (d) Cactus

342. The internal factor of transpiration is: **(PMET Punjab 2003)**
(a) Oxygen (b) Nitrogen
(c) CO_2 (d) Sunken stomata

343. Process of water coming out from specific holes in margins is: **(AFMC 2003)**
(a) Photosynthesis (b) Guttation
(c) Transpiration (d) Bleeding

ANSWERS

1—c	2—c	3—b	4—c	5—c	6—d	7—c	8—b	9—c	10—c	11—d	12—c
13—a	14—b	15—c	16—d	17—b	18—b	19—c	20—d	21—a	22—d	23—b	24—c
25—a	26—d	27—c	28—b	29—a	30—d	31—c	32—d	33—b	34—d	35—b	36—c
37—b	38—c	39—b	40—d	41—c	42—d	43—b	44—d	45—c	46—d	47—d	48—b
49—b	50—c	51—b	52—c	53—b	54—c	55—d	56—d	57—b	58—b	59—c	60—c
61—d	62—b	63—c	64—d	65—c	66—b	67—c	68—c	69—b	70—c	71—b	72—d
73—c	74—b	75—a	76—c	77—a	78—a	79—a	80—d	81—c	82—d	83—b	84—b
85—b	86—d	87—c	88—c	89—b	90—d	91—d	92—a	93—a	94—b	95—c	96—b
97—c	98—a	99—d	100—d	101—b	102—d	103—b	104—b	105—b	106—b	107—d	108—b
109—b	110—c	111—b	112—b	113—a	114—b	115—c	116—d	117—d	118—a	119—c	120—d
121—d	122—c	123—b	124—c	125—b	126—c	127—c	128—b	129—b	130—b	131—a	132—b
133—c	134—c	135—c	136—d	137—c	138—d	139—a	140—b	141—b	142—b	143—b	144—a
145—c	146—b	147—c	148—a	149—a	150—b	151—d	152—c	153—c	154—c	155—c	156—c
157—c	158—a	159—a	160—c	161—a	162—b	163—d	164—c	165—b	166—c	167—b	168—a
169—d	170—b	171—a	172—d	173—b	174—d	175—b	176—b	177—a	178—c	179—a	180—b
181—a	182—d	183—a	184—b	185—c	186—c	187—a	188—a	189—d	190—c	191—b	192—a
193—a	194—a	195—b	196—a	197—a	198—c	199—c	200—a	201—a	202—a	203—c	204—c
205—b	206—b	207—c	208—c	209—b	210—c	211—c	212—b	213—a	214—b	215—d	216—b
217—b	218—a	219—b	220—b	221—c	222—d	223—a	224—c	225—b	226—d	227—c	228—d
229—d	230—a	231—c	232—d	233—b	234—c	235—b	236—b	237—c	238—b	239—b	240—d
241—a	242—d	243—a	244—a	245—d	246—c	247—d	248—b	249—a	250—b	251—a	252—c
253—a	254—d	255—c	256—a	257—d	258—d	259—c	260—d	261—c	262—a	263—b	264—c
265—c	266—a	267—b	268—c	269—c	270—a	271—d	272—a	273—c	274—c	275—b	276—d
277—c	278—b	279—d	280—c	281—c	282—a	283—a	284—d	285—b	286—d	287—b	288—d
289—d	290—a	291—d	292—c	293—b	294—b	295—a	296—a	297—d	298—a	299—b	300—a
301—a	302—a	303—d	304—a	305—b	306—a	307—a	308—c	309—b	310—a	311—a	312—c
313—d	314—c	315—b	316—b	317—b	318—d	319—b	320—c	321—b	322—d	323—d	324—d
325—b	326—a	327—d	328—c	329—b	330—c	331—b	332—c	333—c	334—d	335—a	336—b
337—d	338—a	339—b	340—b	341—d	342—d	343—b					

EXPLANATION OF SELECTED QUESTIONS (*)

26. Guard cells are specialized epidermal cells containing chloroplasts.

77. On a hot dry windy day, the external atmosphere dries which leads to increase in vapour pressure gradient between internal atmosphere of leaf and external atmosphere and thus transpiration rate is increased.

84. Stomata of most of the plants close during night and hence stomatal transpiration is stopped at night.

89. Blue light promotes the movement of K^+ ions into guard cells and thus leads to wider opening of stomata.

91. With increase in height above sea level, atmospheric pressure goes on decreasing, which leads to increase in the rate of transpiration.

132. Guttation is the characteristic of mesophytic herbs.

144. Maximum transpiration occurs in mesophytes.

146. Water lost in guttation is impure containing sugars and salts.

152. A potometer works on the principle that absorption is proportional to transpiration.

159. Scotoactive stomata (which open during night and close during day time) occur in succulents like *Agave, Aloe, Opuntia,* etc.

177. Thin leaf mesophytes or grasses have oat type or barley type of stomata (equally distributed on both surfaces of leaf).

185. CO_2 concentration regulates stomatal movements and hence transpiration.

193. Role of single ion channels in cell was discovered by Nehar and Sakmann, for which they were awarded Nobel Prize in 1991.

204. EDTA (Chelate) is used as buffer in tissue cultures.

247. Cystein, cystine and methionine are sulphur containing amino acids.

253. Plant ash contains only inorganic substances or minerals.

273. Symptoms caused by deficiency of essential mineral elements on plants are called Hunger signs.

275. Under stress conditions, ABA causes partial closure of stomata and thus reduces the loss of water through transpiration.

289. Elements like Cu, Fe, Mn, Mo, etc., act as cofactors of different enzymes, hence enzyme catalyzed reactions can be inhibited by Cu^{2+} deficiency.

306. Scotoactive stomata (opening at night) occur in xerophytic succulents.

311. For phosphorylation or ATP formation, N and P are used.

315. According to Zelitch (1963), at low CO_2 concentration, glycollic acid becomes an important factor for opening of stomata as glycolates form carbohydrates which increase O.P.

323. Loss of water in the form of vapours is transpiration.

bye Products of
Photosynthesis are $O_2 + H_2O$.
2 Photo —
radient energy is converted to
chemical energy

23

Plant Physiology (III)

PHOTOSYNTHESIS

- ☐ General concept of photosynthesis
- ☐ Significance of photosynthesis
- ☐ Historical background
- ☐ **Mechanism of photosynthesis :** Light reaction of photosynthesis (Red drop, Emerson enhancement effect, production of assimilatory powers), dark reaction of photosynthesis (Calvin or C-3 cycle, Hatch and Slack's or C-4 cycle)
- ☐ CAM plants
- ☐ Law of limiting factors
- ☐ Warburg's effect
- ☐ CO_2 compensation point
- ☐ Factors affecting photosynthesis
- ☐ Bacterial photosynthesis
- ☐ Chemosynthesis

PHOTOSYNTHESIS

Green plants have capacity of manufacturing their food from simple substances as CO_2 and H_2O in presence of light.

Photosynthesis is simply defined as, **"formation of carbohydrates from CO_2 and H_2O by illuminated green cells of plants, O_2 and H_2O are the bye products."** or capture of photons of light by green plant cells and conversion of their **radiant energy into chemical form of energy** is called photosynthesis.

Earlier, photosynthesis was considered to be reverse of respiration, *i.e.,*

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

But **Ruben and Kamen** (1941) experimentally verified that source of liberated O_2 in photosynthesis is H_2O and not CO_2.

So it has led to a change in overall general equation of photosynthesis, because $6H_2O$ molecules are not sufficient to evolve $6O_2$ mols. and now general = n of photosynthesis is:

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2 \uparrow + 6H_2O$$

- About 90% of total photosynthesis in world is done by algae in oceans and in freshwater. Further CO_2 fixed annually through photosynthesis is about $7 \cdot 0 \times 10^{13}$ kg.

Significance of photosynthesis

1. It maintains the equilibrium of O_2 in atmosphere.
2. It provides food directly or indirectly.
3. It provides huge source of energy for mankind in the form of coal, petroleum wood, etc.

Historical background

Before 17th century, it was thought that plants obtain their food from soil.

Von Helmont (1648) concluded that plants obtain their nutrition from rain water (not from soil).

Stephen Hales (Father of Plant Physiology) (1727) reported that plants obtain a part of their nutrition from air and light may also play a role in this process.

Priestley (1772) reported that plants have capacity of purifying foul air (while working on **mint** plant).

Ingenhousz (1779) reported that only green plants have capacity of purifying foul air, only in presence of light.

Jean Senebier (1782) reported that plants absorb CO_2 and evolve O_2 in the presence of light.

Nicholas de Saussure (1804) recognized role of water in photosynthesis, *i.e.,* plants also use water as raw material in photosynthesis.

Julius Robert Mayer (1845) recognized role of light in photosynthesis.

Boushingault (1860) reported that amount of O_2 evolved in photosynthesis is equal to amount of CO_2 absorbed and both these processes occur simultaneously as soon as light is given.

Julius Sachs (1864) reported that photosynthesis occurs in chloroplast and form starch.

Stroma → Dense fluid within Chloroplast

H_2O - oxi
CO_2 - reduced.
Granum{ – Thylakoid

Mechanism of photosynthesis

Photosynthesis is actually oxidation reduction process in which water is oxidised and CO_2 is reduced to carbohydrates.

- The reduction of CO_2 to carbohydrates needs assimilatory powers, *i.e.*, ATP and $NADPH_2$.
- Actual reduction of CO_2 to carbohydrates is independent of light, *i.e.*, occurs in presence or absence of light, but production of assimilatory powers (ATP and $NADPH_2$) needs light and is light dependent.

(a) **Light dependent phase or Photochemical reaction or Light reaction or Hill's reaction.**

(b) **Light independent phase or Purely chemical reaction or Dark reaction or Blackman's reaction.**

Evidences in favour of 2 phases in photosynthesis are:

1. Physical separation of chloroplast into grana and stroma fractions : It is now possible to separate grana and stroma fractions of chloroplast. If light is given to grana fraction in presence of suitable H-acceptor and in complete absence of CO_2, then ATP and $NADPH_2$ are produced (*i.e.*, assimilatory powers).

If these assimilatory powers (ATP and $NADPH_2$) are given to stroma fraction in presence of CO_2 and absence of light, then carbohydrates are formed.

2. Experiments with intermittent light or Discontinuous light : Rate of photosynthesis is faster in intermittent light (alternate light and dark periods) than in continuous light. It is because light reaction is much faster than dark reaction, so in continuous light, there is accumulation of ATP and $NADPH_2$ and hence reduction in rate of photosynthesis but in discontinuous light, ATP and $NADPH_2$ formed in light are fully consumed during dark in reduction of CO_2 to carbohydrates.

3. Temperature coefficient study : Temperature coefficient (Q_{10}) value in photosynthesis is found to be 2 when photosynthesis is fast but Q_{10} is 1 when photosynthesis is slow. These 2 values of Q_{10} show 2 phases or reactions in photosynthesis.

Source of O_2 liberated in photosynthesis

This is **water** and not CO_2. This was experimentally confirmed by **Ruben and Kamen** (1941), while working on *Chlorella* alga (unicellular green alga) using radioactive isotopes of oxygen, *i.e.*, ^{18}O.

(i) When normal H_2O and radioactive CO_2 (*i.e.*, $C^{18}O_2$) were used, normal O_2 is evolved.

$$C^{18}O_2 + 2H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} (CH_2O) + \underset{\text{(normal)}}{O_2\uparrow} + H_2O$$

$$\text{(ii) } CO_2 + 2H_2{}^{18}O \xrightarrow[\text{Chlorophyll}]{\text{Light}} (CH_2O) + \underset{\substack{\text{radioactive}\\\text{oxygen}}}{{}^{18}O_2\uparrow} + H_2O$$

i.e., when normal CO_2 and radioactive H_2O ($H_2{}^{18}O$) were used, radioactive oxygen ($^{18}O_2$) is evolved.

(A) Light reaction or Hill's reaction or Photochemical reaction

Light reaction occurs in **grana fraction** of chloroplast and in this reaction are included those activities, which are dependent on light. Assimilatory powers (ATP and $NADPH_2$) are mainly produced in this light reaction.

Two pigment systems : There are 2 photoacts or pigment systems in light reaction of photosynthesis, *i.e.*, PS-I and PS-II. PS-I is essential for producing the reduced NADP (*i.e.*, $NADPH_2$) used to reduce CO_2, whereas PS-II oxidizes water and releases O_2.

- Evidence in favour of 2 pigment systems comes from studies of **Robert Emerson** and his co-workers (*i.e.*, Red drop and Emerson enhancement effect).
- Rate or yield of photosynthesis is measured in terms of **quantum yield** or O_2 evolution, which may be defined as, "Number of O_2 mols.evolved per quantum of light absorbed in photosynthesis."

On the other hand **quantum requirement** is defined as, "Number of quanta of light required for evolution of one mol of O_2 in photosynthesis."

- **Quantum requirement** in photosynthesis = 8
  i.e., 8 quanta of light are required to evolve one mol. of O_2.
- Hence **quantum yield** = $\frac{1}{8}$ = 0·125 (*i.e.*, a fraction of 1)

Red drop

Action spectrum (effect of different wave lengths of light on quantum yield) of photosynthesis shows that quantum yield is slightly dropped in the region **440–520 nm**, remains constant and **maximum in region 600–680 nm**, but there is sudden fall or drop in quantum yield above 680 nm. This sudden drop or fall in rate of photosynthesis or in quantum yield above 680 nm (far red light) is called **red drop.** This phenomenon was discovered by **Emerson and Lewis** (1943).

Emerson enhancement effect

Emerson *et al.* (1957) discovered that far red light (above 680 nm), which is photosynthetically inefficient can be made efficient by supplementing it with a beam of shorter wave length (red beam below 680 nm). Further the quantum yield in combined beam (far red + red) is more than sum total of quantum yields in two separate beams.

This enhancement in quantum yield by supplementing far red light with red light is called **Emerson enhancement effect** (*E*).

$$E = \frac{\text{Quantum yield in combined beam} - \text{Quantum yield in red beam}}{\text{Quantum yield in far red beam}}$$

Further researches on red drop and Emerson enhancement effect established that there are 2 pigment systems in photosynthesis, *i.e.*, PS-I and PS-II. Upto 680 nm of light, both PS-I and PS-II are active (hence high quantum yield) but above 680 nm, only PS-I is active (hence quantum yield is dropped).

- **PS-I** is having pigments as Chl.–a 660, Chl.–a 670, Chl.–a 680, Chl.–a 690, Chl.–a 700 and carotenoids (Chl.–a 700 or P_{700} is the reaction centre of PS-I).
- **PS-II** is having pigments as Chl.–b 650, Chl.–a 660, Chl.–a 670, Chl.–a 678, Chl.–a 680–690 and phycobilins ($P_{680-690}$ is the reaction centre of PS-II).

Production of assimilatory powers

Arnon (1956) used the term 'Assimilatory Powers' for **ATP** and **$NADPH_2$**. ($NADPH_2$ alone is called reducing power).

- Reduction of NADP to $NADPH_2$ is called ETS in photosynthesis and production of ATP in presence of light is called photophosphorylation.

(a) Reduction of NADP to $NADPH_2$: Fd (ferredoxin) is responsible for reduction of NADP to $NADPH_2$, but it alone cannot reduce NADP and needs flavoprotein enzyme (*i.e.*, **Fd-NADP reductase**).

- Fd is reduced by PS-I (P_{700}) via A (FeS), *i.e.*, iron sulphur protein complex. PS-I is reduced by Cyt.f and PC (Plastocyanin) and plastocyanin (PC) acts as a plug between PS-I and PS-II. PC is a copper containing protein.

PC and Cyt. f are reduced by PS-II and PS-II is reduced by pulling electrons from water, due to which **'photolysis of H_2O**, takes place. Photolysis of H_2O is helped by Mn and Cl.

$$4H_2O \longrightarrow 4H^+ + 4OH^-$$

$$4OH^- \longrightarrow 4(OH) + 4e^-$$

$$4(OH) \longrightarrow 2H_2O + O_2\uparrow$$

$$2H_2O \longrightarrow 4H^+ + 4e^- + O_2\uparrow$$

The electrons released in photolysis of H_2O are used for reducing PS-II. H^+ ions are used for reduction of NADP to $NADPH_2$ and O_2 is evolved.

(b) Photophosphorylation : Arnon *et al.* (1954) first of all demonstrated that isolated chloroplasts can produce ATP from ADP + ip and they called this ATP production as **'photophosphorylation'** (Light dependent and O_2 independent).

ATP in photosynthesis is required at 2 places:

(i) ATP provides energy for the reduction of CO_2 to carbohydrates by utilizing $NADPH_2$.

(ii) Needed for conversion of Ribulose-5-PO_4 to Ribulose-1, 5-diphosphate (*i.e.*, RuBP or RuDP).

Photophosphorylation is of 2 types:

1. Cyclic photophosphorylation : It involves only **PS-I**. Here electrons released from P-700 move through A (FeS), Cyt. b_6, PQ (plastoquinone), Cyt. f, PC (plastocyanin) and are recycled back to P-700. One ATP molecule is produced between A (FeS) and Cyt. b_6 and another ATP is produced between Cyt. b_6 and Cyt. f. Further no H_2O is utilized and hence no O_2 evolution occurs.

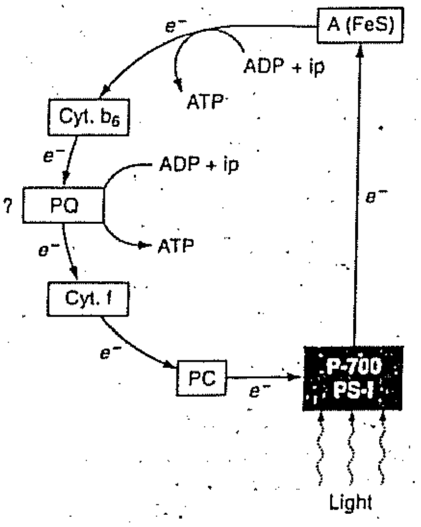


Fig. 23.1. Cyclic photophosphorylation

- Cyclic photophosphorylation is the most effective anaerobic phosphorylation mechanism.

2. Non-cyclic photophosphorylation : It involves both **PS-I** and **PS-II**. Here electrons are not cycled back and are used in the reduction of NADP to $NADPH_2$. Here H_2O is utilized and O_2 evolution occurs. Only one ATP molecule is produced between PQ and Cyt. f.

- This non-cyclic photophosphorylation is also known as **Z-scheme** (because of shape of path of electron-flow) and this was given by **Hill and Bendall** (1960).

Non-cyclic photophosphorylation or Z-scheme is inhibited by **CMU** and **DCMU**. (Fig. 23.2)

(**DCMU** is a herbicide which kills the weed by inhibiting CO_2 fixation as it is a strong inhibitor of PS-II).

Differences between cyclic and non-cyclic photophosphorylation

(i)	Only PS-I is involved.	(i)	Both PS-I and PS-II are involved.
(ii)	Water is not utilized.	(ii)	Water is utilized.
(iii)	No evolution of O_2.	(iii)	O_2 is evolved.
(iv)	2 ATP mols. are produced and no $NADPH_2$.	(iv)	1 ATP mol. and 1 $NADPH_2$ are produced.

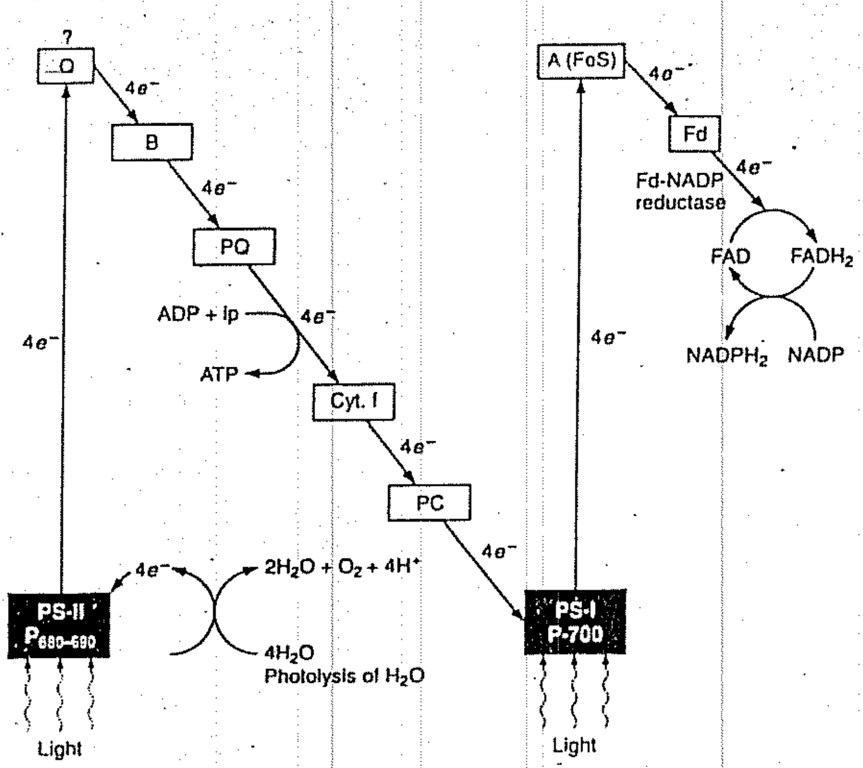


Fig. 23.2. Non-cyclic photophosphorylation (Z-scheme)

(B) Dark reaction

Dark reaction of photosynthesis occurs in presence or absence of light (*i.e.*, **independent of light**).

- Dark reaction occurs in **stroma fraction** of the chloroplast. Dark reaction is **purely enzymatic reaction** and is slower than light reaction of photosynthesis.
- Dark reaction was first of all established by **F. F. Blackman** (1905) and later on studied in detail by **Dr. Calvin, Benson and J. Bassham** and for this work they were given **Nobel Prize** (1961).

The techniques used for studying different steps were **Radioactive tracer technique** using ^{14}C (half life – 5720 years), **Chromatography** and **Autoradiography** and the material used was *Chlorella* (Cloacal alga) and *Scenedesmus* (these are microscopic, unicellular algae and can be easily maintained in laboratory).

- Dark reaction of photosynthesis is variously named as **Blackman's reaction, Calvin cycle or Path of C-assimilation or Path of C in photosynthesis**, etc.

Calvin cycle or C-3 cycle or Reductive pentose phosphate cycle

This path of C-assimilation was given by Calvin, Benson and Bassham (1949). This is also known C-3 cycle because CO_2 reduction is cyclic process and first stable product in this cycle is a **3-C compound** (*i.e.*, 3-Phosphoglyceric acid-or 3-PGA).

- In this cycle, CO_2 acceptor molecule is **RuBP** or **RuDP** (*i.e.*, Ribulose 1, 5-biphosphate or Ribulose 1, 5-diphosphate). There occurs covalent bonding of CO_2 to RuBP and the enzyme catalyzing this reaction is RuBP-carboxylase/oxygenase(Rubisco).
- As Calvin cycle takes in only one carbon (as CO_2) at a time, so it takes **six turns** of the cycle to produce a net gain of six carbons (*i.e.*, hexose or glucose).
- In this cycle, for formation of one mole of hexose sugar (Glucose), **18 ATP and 12 $NADPH_2$** are used.
- The plants in which this pathway of CO_2 reduction occurs, are called **C-3 plants.**
- **About 85% of plant species are C-3 plants, including** cereals (*e.g.*, barley, rice, oat, wheat), groundnut, sugarbeet, cotton, tobacco, spinach, soybean, most trees and lawn grasses, etc.

This path of CO_2-fixation or C-assimilation is as shown in Fig. 23.3.

Hatch and Slack's cycle or C-4 cycle

For a long time, Calvin cycle (C-3 cycle) was considered to be the only photosynthetic pathway for reduction of CO_2 into carbohydrates. **Kortschak, Hartt and Burr** (1965)

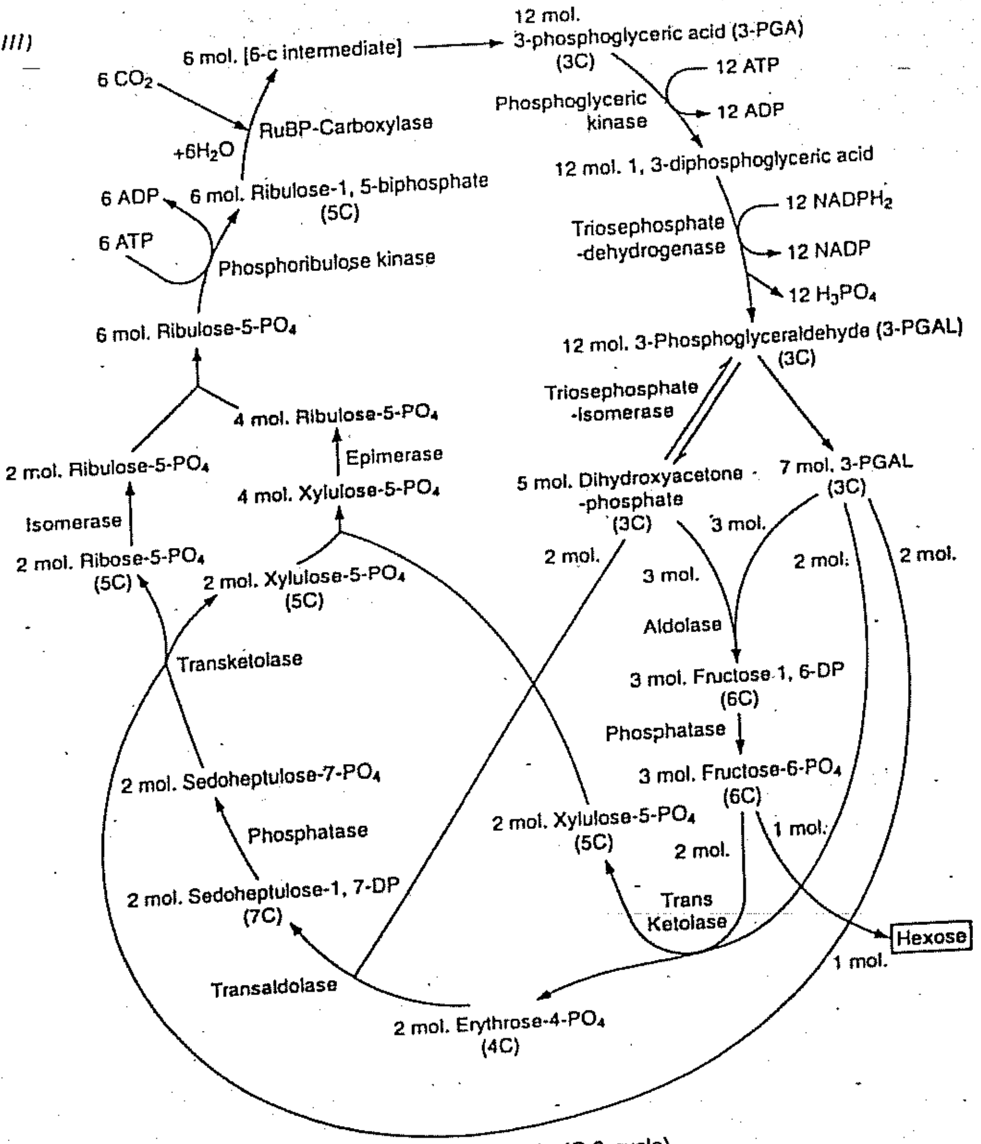

12 mol.
3-phosphoglyceric acid (3-PGA)
(3C)
6 mol. [6-c intermediate]
6 CO_2
RuBP-Carboxylase
+6H_2O
12 ATP
Phosphoglyceric kinase
12 ADP
12 mol. 1, 3-diphosphoglyceric acid
6 ADP
6 mol. Ribulose-1, 5-biphosphate
(5C)
6 ATP
Phosphoribulose kinase
12 $NADPH_2$
Triosephosphate -dehydrogenase
12 NADP
12 H_3PO_4
6 mol. Ribulose-5-PO_4
12 mol. 3-Phosphoglyceraldehyde (3-PGAL)
(3C)
Triosephosphate -Isomerase
4 mol. Ribulose-5-PO_4
Epimerase
2 mol. Ribulose-5-PO_4
4 mol. Xylulose-5-PO_4
5 mol. Dihydroxyacetone -phosphate
(3C)
7 mol. 3-PGAL
(3C)
Isomerase
2 mol. Ribose-5-PO_4
(5C)
2 mol. Xylulose-5-PO_4
(5C)
2 mol.
3 mol.
3 mol.
2 mol.
2 mol.
Aldolase
Transketolase
3 mol. Fructose 1, 6-DP
(6C)
Phosphatase
2 mol. Sedoheptulose-7-PO_4
3 mol. Fructose-6-PO_4
(6C)
Phosphatase
2 mol. Xylulose-5-PO_4
(5C)
1 mol.
2 mol.
2 mol. Sedoheptulose-1, 7-DP
(7C)
Trans Ketolase
Hexose
1 mol.
Transaldolase
2 mol. Erythrose-4-PO_4
(4C)

Fig. 23.3. Calvin cycle (C-3 cycle)

reported that rapidly photosynthesizing sugar cane leaves produced a 4-C compound like aspartic acid and malic acid as a result of CO_2-fixation.This was later supported by **M.D. Hatch and C.R. Slack (1966)** and they reported that a 4-C compound **oxaloacetic acid (OAA) is the first stable product** in CO_2 reduction process. This occurs only after 1 sec of photosynthesis, although on longer exposures, 3-PGA is formed.

This led to an alternative pathway of CO_2 fixation, which is known as **Hatch and Slack's cycle or C-4 cycle** (as 4-C compound is first stable product). (Fig. 23.5)

This pathway was first reported in members of family **Gramineae** (grasses) like sugar cane, maize, sorghum, etc., **(Tropical grasses)** but later on in other sub-tropical plants also like *Atriplex* and *Amaranthus*. All known C-4 plants are **angiosperms** and these are common in bright, hot and open ecosystems. There are no known C-4 gymnosperms, bryophytes or algae.

- Genera like *Flaveria* (Asteraceae), *Panicum*, *Alternanthera* and *Atriplex* contain both C-3 and C-4 species as well as species intermediate between C-3 and C-4 photosynthesis. These C_3-C_4 intermediates have reduced photorespiration and intermediate leaf anatomy.

These C-4 plants have a characteristic leaf anatomy called **Kranz anatomy (Wreath anatomy**- in German meaning ring or **Halo anatomy)**.

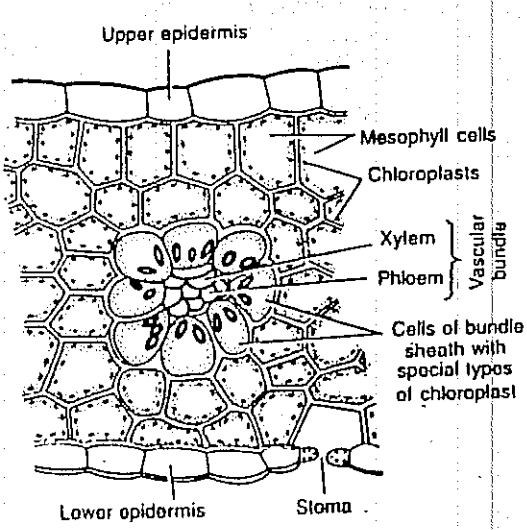

Upper epidermis
Mesophyll cells
Chloroplasts
Xylem
Phloem
Vascular bundle
Cells of bundle sheath with special types of chloroplast
Lower epidermis
Stoma

Fig. 23.4. Leaf showing kranz anatomy

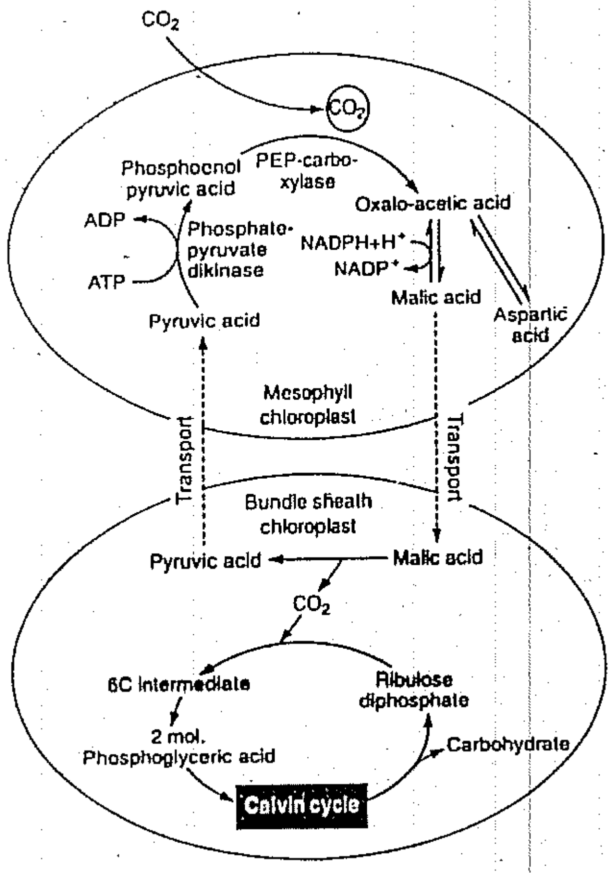

CO_2
CO_2
Phosphoenol pyruvic acid
PEP-carbo-xylase
Oxalo-acetic acid
ADP
ATP
Phosphate-pyruvate dikinase
NADPH+H⁺
NADP⁺
Malic acid
Aspartic acid
Pyruvic acid
Mesophyll chloroplast
Transport
Transport
Bundle sheath chloroplast
Pyruvic acid
Malic acid
CO_2
6C Intermediate
Ribulose diphosphate
2 mol. Phosphoglyceric acid
Carbohydrate
Calvin cycle

Fig. 23.5. Hatch and slack's cycle (C-4 cycle)

Here vascular bundles are surrounded by sheaths of large parenchymatous cells called **bundle sheaths**, which are surrounded by mesophyll cells. So here **two types of chloroplasts** are present, *i.e.*,

(i) **Bundle sheath chloroplasts :** Larger in size, lack grana (Agranal chloroplasts) and contain starch grains.

(ii) **Mesophyll chloroplasts :** Smaller in size, contain grana and lack starch grains.

Further these cells are connected by plasmodesmata.

- Here in C-4 plants, there are **2 carboxylation reactions**, first in mesophyll chloroplast and second in bundle sheath chloroplast.
- CO_2 acceptor molecule here is **PEP** (phospho-enol pyruvate) and not RuBP. Further, **PEP-carboxylase (PEPCO)** is the key enzyme (RuBP-carboxylase enzyme is negligible or absent in mesophyll chloroplast, but is present in bundle sheath chloroplast).
- In C-4 plants, for formation of one mole of hexose (glucose), **30 ATP** and **12 NADPH₂** are required.

Significance of C-4 cycle : This C-4 cycle is helpful to plants growing in dense tropical forests, where there is poor supply of CO_2. Because here there is internal supply of CO_2, so these plants can survive in poor CO_2 conditions. Further photorespiration is negligible or absent in C-4 plants and present only in C-3 plants. So C-4 plants are **photosynthetically more efficient.**

CAM plants (Crassulacean acid metabolism plants)

Compensation Point

This metabolism was first of all reported in *Bryophyllum*, a member of family **Crassulaceae** and hence is called crassulacean acid metabolism.

This occurs in mostly **succulents** (xerophytes) like *Opuntia, Agave, Aloe, Sedum, Kalanchoe*, etc. In these plants, there is no kranz anatomy, but there occurs **dark acidification,** *i.e.*, during night malic acid is formed. This malic acid breaks up into CO_2 and pyruvic acid in day time and CO_2 released is utilized in C-3 cycle.

- In these plants, stomata open during night and close during day time (**Scotoactive stomata**)

Law of limiting factors

This was given by **F.F. Blackman** (1905) and it states:

'When a process is conditioned so as to its rapidly by number of factors, then the rate of the process is determined by pace of slowest factor'. CO_2 is usually a limiting factor in photosynthesis under field conditions particularly on clear summer days under adequate water supply.

Warburg's effect

German scientist **Warburg** (1920) reported in *Chlorella* alga that high O_2 levels inhibit rate of photosynthesis and this

MULTIPLE CHOICE QUESTIONS

1. Which is the correct equation of photosynthesis?
(a) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
[✓ (b) $6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$]
(c) $6CO_2 + 18H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 12H_2O$
(d) None of the above

2. Source of liberated O_2 in photosynthesis is: **(CPMT 1992; MPPMT 2002; Orissa JEE 2002; Kerala PMT 2002)**
(a) CO_2 [✓ (b) H_2O]
(c) Both (a) and (b) (d) None of these

3. 'Plants have capacity of purifying foul air' was reported by:
(a) Stephen Hales (b) Priestley
(c) Julius Robert Mayer (d) Saussure

4. Who recognized the role of light as source of energy in photosynthesis?
(a) Saussure (b) Julius Sachs
(c) Julius Mayer (d) Ingenhousz

5. Photosynthesis is an oxidation-reduction process, in which ...... is oxidised:
(a) CO_2 [✓ (b) H_2O]
(c) Both (a) and (b) (d) None of these

6. Full form of NADP is:
(a) Nicotine adenine diphosphate
(b) Nicotinamide adenosine dinucleotide phosphate
[✓ (c) Nicotinamide adenine dinucleotide phosphate]
(d) Nicotinamide adenine diphosphate

7. Evidence for existence of two pigment systems in light reaction was given by:
(a) Arnon (b) Emerson
(c) Sachs (d) Calvin

8. The quantum yield in photosynthesis is:
[✓ (a) More than 1] (b) 1
(c) Less than 1 (d) 0

9. 'Red drop' effect is shown at which wave length of light?
(a) 620 nm (b) 660 nm
(c) 680 nm [✓ (d) More than 680 nm]

10. The phenomenon of 'Red drop' was discovered by:
(a) Emerson [✓ (b) Emerson and Lewis]
(c) Arnon (d) Blackman

11. Which is 'reaction centre' of PS–I?
(a) P_{690} (b) P_{682}
(c) P_{700} (d) None of these

12. (Chl.–b 650 + Chl.–a 660 + Chl.–a 670 + Chl.–a 678 + Chl.–a 680–690) represent:
(a) PS-I [✓ (b) PS-II]
(c) Both the systems (d) None of these

13. Term 'Assimilatory powers' was given by:
(a) Emerson (b) Lewis
(c) Arnon (d) Ruben and Kamen

14. Assimilatory powers in photosynthesis are: **(BHU 1991)**
(a) ATP and $NADH_2$ (b) $NADPH_2$ and ADP
[✓ (c) ATP and $NADPH_2$] (d) $NADPH_2$

15. Immediate electron acceptor from PS-I is:
(a) Fd (b) NADP
[✓ (c) A (FeS)] (d) Q

16. Electron donor to PS-I is:
(a) Cyt. f (b) Plastocyanin
(c) Cyt. b_6 (d) Fd

*17. Photolysis of water is caused by:
(a) PS–I (b) PS–II
(c) PS–I and PS–II (d) None of these

18. Photolysis of water is helped by: **(Kerala PMT 2002)**
(a) Mg and Cl [✓ (b) Mn and Cu]
[✓ (c) Mn and Cl] (d) None of these

19. 'Z-scheme' of electron transfer and photophosphorylation was given by:
(a) Arnon [✓ (b) Hill]
(c) Hill and Bendell (d) Blackman and Hill

20. O_2 evolution and $NADPH_2$ synthesis occurs in: **(Raj. PMT 2001)**
(a) Cyclic photophosphorylation
[✓ (b) Non-cyclic photophosphorylation]
(c) Both (a) and (b)
(d) None of the above

21. Number of ATP molecules and $NADPH_2$ molecules produced in cyclic photophosphorylation:
(a) 1 and 1 (b) 1 and 2
(c) 2 and 1 [✓ (d) 2 and 0]

22. Non-cyclic photophosphorylation and O_2 evolution are inhibited by:
(a) 2, 4-Dinitrophenol (b) CMU
[✓ (c) DCMU] (d) Both (b) and (c)

*23. Which is not correct for cyclic photophosphorylation?
(a) No O_2 given off
(b) No water consumed
(c) No $NADPH_2$ synthesized
[✓ (d) PS–I and PS–II are involved]

24. Dark reaction of photosynthesis occurs in:
(a) Presence of light
(b) Absence of light
[✓ (c) Absence or presence of light]
(d) None of the above

25. Dark reaction occurs in: **(CPMT 1998; MPPMT 2000)**
(a) Grana [✓ (b) Stroma]
(c) Both (a) and (b) (d) None of these

26. Dark reaction was first established by:
(a) Arnon [✓ (b) Blackman]
(c) Bassham (d) Calvin

27. Who was not awarded Nobel Prize for path of C-assimilation?
(a) Benson (b) Calvin
(c) Hatch (d) Bassham

28. Dr. Calvin used ...... plant for his studies :
[✓ (a) *Chlorella*] (b) *Scenedesmus*
(c) *Plagiochasma* (d) Both (a) and (b)

29. First stable product in C-3 cycle is: (BHU 1992; CPMT 2000; MPPMT 2000)
(a) PGAL [✓ (b) PGA]
(c) Glucose (d) OAA

30. The CO_2 acceptor molecule in Calvin-Benson pathway is: (Raj. PMT 2002)
(a) Phospho-glyceric acid
(b) Phospho-enol pyruvic acid
(c) RuBP
(d) OAA

31. How many ATP and $NADPH_2$ are required for synthesis of one mole of glucose? (CPMT 1991)
(a) 12 ATP and 12 $NADPH_2$
(b) 12 ATP, 18 $NADPH_2$
(c) 18 ATP and 12 $NADPH_2$
(d) None of the above

*32. Asymmetric lebelling of glucose phosphate formed in photosynthesis is called:
(a) Warburg's effect (b) Pasteur's effect
(c) Gibb's effect (d) Dickens' effect

33. Which is a C-4 plant? (MPPMT 1993, 95)
(a) Wheat (b) Potato
(c) Sunflower [✓ (d) Maize]

34. Which of the following is both C-3 and C-4 plant?
(a) Sugar cane (b) Maize
(c) *Atriplex* (d) *Chenopodium*

35. 'Wreath anatomy' is feature of:
(a) Temperate grasses (b) Tropical grasses
(c) Both (a) and (b) (d) None of these

36. The bundle sheath chloroplasts are:
(a) Larger in size (b) Lack grana
(c) Have starch grains [✓ (d) All of these]

37. Two carboxylation reactions occur in:
(a) C-3 plants
(b) C-4 plants
(c) Both C-3 and C-4 plants
(d) C-2 plants

38. First carboxylation reaction in sugar cane leaves occur in:
[✓ (a) Mesophyll chloroplast]
(b) Bundle sheath chloroplast
(c) Either of two
(d) Both mesophyll and bundle sheath chloroplast

39. High CO_2 compensation point is found in:
(a) C–3 plants [✓ (b) C–4 plants]
(c) Both (a) and (b) (d) None of these

40. Which are photosynthetically more efficient plants?
[✓ (a) C–4] (b) C–3
(c) C–2 (d) C–1

41. C–2 cycle is characteristic of:
(a) C–3 plants
(b) C–4 plants
(c) Both C–3 and C–4 plants
[✓ (d) None of the above]

*42. Malic acid (4-C) is produced in which plant without Kranz anatomy?
[✓ (a) *Bryophyllum* plant] (b) *Kalanchoe* plants
(c) *Opuntia* plants (d) All of these

43. Identification of C_4 plants is with the: (AIIMS 1993)
(a) Presence of stomata
[✓ (b) Presence of bundle sheath chloroplast]
(c) Presence of thick cuticle
(d) Presence of thick hairs

44. Inhibition of photosynthesis by high O_2 levels is called:
(a) Gibb's effect [✓ (b) Warburg's effect]
(c) Pasteur's effect (d) None of these

45. The CO_2 compensation point in C–4 plants is:
(a) Below 20 ppm [✓ (b) 25–100 ppm]
(c) Less than 5 ppm (d) None of these

*46. Calvin cycle expends the following for fixation of 3-molecules of CO_2: (AIIMS 1994)
(a) 9 ATP and 6 $NADPH_2$ (b) 8 ATP and 6 $NADPH_2$
(c) 9 ATP and 3 $NADPH_2$ (d) 6 ATP and 9 $NADPH_2$

47. Rate of photosynthesis is measured by:
(a) Photometer (b) Moll's half-leaf method
[✓ (c) Wilmott's bubbler] (d) Ganong's screen method

48. The rate of photosynthesis is highest in: (CPMT 1990)
(a) Red light (b) Blue light
(c) Green light (d) Polychromatic light

49. Warburg experimented upon:
(a) *Scenedesmus* (b) Cloacal alga
(c) *Nostoc* [✓ (d) *Hydrilla*]

*50. The key compound of Calvin cycle is:
(a) PGA (b) PGAL
(c) DHAP (d) DPGA

51. Photosynthesis takes place in chloroplast was reported by:
(a) Saussure (b) Englemann
(c) J. Sachs (d) Mayer

52. Photosynthesis uses what % of light? (CPMT 1992)
(a) 10% (b) 35%
(c) 50% (d) 1%

53. In Hill's reaction:
(a) CO_2 is produced
(b) ADP formed
(c) $NADPH_2$ formed
(d) ATP and $NADPH_2$ formed

54. Artificial light can:
(a) Destroy chlorophyll
(b) Synthesize chlorophyll
[✓ (c) Bring about photosynthesis]
(d) Not bring about photosynthesis

55. Very strong light has a direct inhibiting effect on photosynthesis, which is known as:
(a) Chlorosis (b) Etiolation
(c) Defoliation (d) Solarization

56. 9/10th of world's photosynthesis is carried out by : (St. Johns 2002)
(a) Shrubs (b) Herbs
[✓ (c) Algae] (d) Trees

inhibition of photosynthesis by increased O_2 concentration is called **Warburg's effect**. This is due to competitive inhibition of RuBP-carboxylase by increased O_2 levels, *i.e.*, O_2 competes for active sites of RuBP-carboxylase enzyme with CO_2.

CO_2 compensation point

In photosynthesis, CO_2 is utilized in presence of light to release O_2 whereas in respiration, O_2 is taken and CO_2 is released. If light factor is saturating, there will be certain CO_2 concentration at which rate of photosynthesis is just equal to rate of respiration or photosynthesis just compensates respiration or apparent photosynthesis is nil. It is called CO_2 compensation point.

- CO_2 compensation point is very low in C-4 plants, *i.e.*, 0 to 5 ppm whereas high CO_2 compensation point is found in C-3 plants, *i.e.*, **25 to 100 ppm.**

Some points to remember

- **Ganong's light screen** is used to prove that light is necessary for photosynthesis.
- **Moll's half leaf experiment** is used to prove that CO_2 is necessary for photosynthesis.
- **Willmott's bubbler** is used to measure rate of O_2 evolution or rate of photosynthesis.

Factors affecting photosynthesis

(A) External factors or Environmental factors

1. Light : Light is the most important factor for photosynthesis because it is used as a source of energy. Normally plants utilize sunlight but marine algae also use moon light, photosynthesis even occurs in electric light.

(a) Quality of light : Photosynthesis occurs in visible part of spectrum, *i.e.*, 3800 Å–7600 Å (380–760 nm).

- In monochromatic lights, maximum photosynthesis occurs in **red light**, followed by **blue light** and poor photosynthesis in **green light**.

(Although photosynthesis is **maximum in polychromatic light** or white light).

- **T.W. Englemann** (1882) experimentally verified that in monochromatic lights, photosynthesis is **maximum in red light.**

(b) Intensity of light : Only **1–4%** light is utilized in photosynthesis. In general, rate of photosynthesis is more in intense light than diffused light. (Upto **10%** light is utilized in **sugar cane**, *i.e.*, most efficient converter).

- Another photosynthetic superstar of field growing plants is *Oenothera claviformis* (winter evening-primrose), which utilizes about 8% light.

However, this light intensity varies from plant to plant, *e.g.*, more in **heliophytes** (sun loving plants) and less in **sciophytes** (shade loving plants). For a complete plant, rate of photosynthesis increases with increase in light intensity, except very high light intensity where **'Solarization'** phenomenon occurs, *i.e.*, **photo-oxidation** of different cellular components including chlorophyll occurs.

- Maximum rate of photosynthesis occurs near noon when light is brightest and at this time, plants usually fix about eight times more CO_2 than is released during respiration (*i.e.*, rate of photosynthesis is eight times more than rate of respiration). Averaged over a day, rate of photosynthesis is about six times more than rate of respiration.

(c) Duration of light : Even a brief flash of light is capable of carrying out photosynthesis. In general, photosynthesis is more in intermittent (discontinuous) light as compared to continuous light.

- Rate of photosynthesis is independent of duration of light.

2. CO_2 : Normal conc. of CO_2 in atmosphere is 0·03% (*i.e.*, 300 ppm). By increasing CO_2 conc. **15 to 20 times**, rate of photosynthesis increases but after that it decreases.

3. Temperature : Generally photosynthesis is inhibited at **0°C** but some conifers even photosynthesize upto **–35°C**. Similarly *Opuntia* photosynthesize upto **55°C** and blue green algae upto **75°C**.

- Q_{10} (temperature coefficient) value for photosynthesis is 2 upto about 40°C and above it, denaturation of enzymes begins and hence rate of photosynthesis decreases.

4. O_2 : (See **Warburg's effect**)

5. H_2O : As less than 1% of total water absorbed by the plant is utilized in photosynthesis, so water rarely acts as limiting factor. In water deficient conditions, photosynthesis is found to be decreased by 87%.

(B) Internal factors

1. Chlorophyll content : If all other factors are favourable, increase in chlorophyll leads to increase in photosynthesis.

- In **varigated leaves**, photosynthesis occurs only in green parts of the leaf.

2. Accumulation of end products : It results in decrease in rate of photosynthesis.

Bacterial photosynthesis

Like green plants, some purple and green sulphur bacteria are capable of synthesizing their organic food in presence of light and in absence of O_2, which is known as **bacterial photosynthesis.**

- Following general equation of bacterial photosynthesis has been given by Van Nell (1950):

$$CO_2 + 2H_2A \xrightarrow[\text{light}]{\text{Bacteriochlorophyll or Chlorobium chlorophyll}} (CH_2O) + \underset{\substack{\text{or} \\ A_2}}{2A} + H_2O$$

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Some important examples of photosynthetic bacteria are:

(i) **Green sulphur bacteria :** *e.g., Chlorobium*. It contains **chlorobium chlorophyll**, which absorb 720–750 nm (far red light) of wavelength of light.

(ii) **Purple sulphur bacteria :** *e.g., Chromatium.*

(iii) **Non-sulphur bacteria :** *e.g., Rhodospirillum.*

Purple sulphur bacteria and non-sulphur bacteria contain **bacteriochlorophyll**, which is having 2H-atoms more than chl.–a and it absorbs **850–950 nm** (infra red) wavelength of light, which is poor in energy and hence unable to use and split H_2O and thus **no O_2 evolution** in bacterial photosynthesis.

Characteristics of bacterial photosynthesis are:

1. No definite chloroplasts but contain simple structures having pigments called **chromatophores.**
2. Contain chlorobium chlorophyll or bacteriochlorophyll.
3. Use longer wave lengths of light (720–950 nm).
4. No utilization of H_2O (but use H_2S or other reduced organic and inorganic substances).
5. No evolution of O_2.
6. Photoreductant is $NADH_2$ (Not $NADPH_2$).
7. Only one photoact and hence one pigment system and thus one reaction centre, *i.e.*, P_{890}.
8. Cyclic photophosphorylation is dominant.
9. It occurs in presence of light and in absence of O_2.

Chemosynthesis

Some aerobic bacteria are capable of manufacturing their organic food, utilizing **chemical energy** released in oxidation of some inorganic substances (not light energy). This phenomenon of formation of organic food utilizing chemical energy is called chemosynthesis.

Some important chemosynthetic bacteria are:

(i) **Nitrifying bacteria,** *e.g., Nitrosomonas, Nitrosococcus* and *Nitrobacter*, etc.

o. *Nitrosomonas* and *Nitrosococcus* oxidise $NH_3 \longrightarrow NO_2^-$ (nitrite) and release chemical energy, which is used in manufacture of their food. *Nitrobacter*, on the other hand oxidize nitrite (NO_2^-) to nitrate (NO_3^-) with release of chemical energy.

(ii) **Sulphur bacteria,** *e.g., Beggiatoa, Thiothrix* and *Thiobacillus.*

They oxidize $H_2S \xrightarrow{[O]} S + H_2O +$ Chemical energy (utilized in formation of food)

(iii) **Iron bacteria,** *e.g., Ferrobacillus, Leptothrix* and *Cladothrix.*

These oxidise $\underset{\text{(Ferrous)}}{Fe^{2+}} \longrightarrow \underset{\text{(Ferric)}}{Fe^{3+}} +$ Chemical energy (used for food formation)

(iv) **Hydrogen bacteria,** *e.g., Bacillus pentotrophus*

$$H_2 \xrightarrow{[O]} (H_2O) + \text{Chemical energy}$$

(used in food formation).

(v) **Carbon bacteria,** *e.g., Bacillus oligocarbophilus*

$$CO \xrightarrow{[O]} CO_2 + \text{Chemical energy}$$

(used in food formation)

*57. The increase in photosynthesis occurs till CO_2 concentration is increased upto:
(a) 300 ppm (b) 600 ppm
(c) 4000 ppm (d) 6000 ppm

58. What % of water absorbed by the plants is utilized in photosynthesis?
(a) 10% (b) 20%
(c) 1% (d) 50%

59. Accumulation of end products in photosynthetic cells leads to:
(a) Increase in photosynthesis
[✓ (b) Decrease in photosynthesis]
(c) Increase or decrease
(d) No effect

60. Maximum enzyme present in chloroplast is:
(a) Hexokinase (b) RuBP-carboxylase
(c) PEP-carboxylase (d) None of these

61. Bacterial photosynthesis occurs in:
(a) Absence of light and O_2
(b) Presence of light and O_2
(c) Absence of light and presence of O_2
(d) Absence of O_2 and presence of light

62. Which is non-sulphur photosynthetic bacteria?
(a) *Chlorobium* (b) *Chromatium*
(c) *Rhodospirillum* (d) None of these

63. Chlorobium chlorophyll absorbs which wavelength of light?
(a) 850–950 nm (b) Upto 680 nm
(c) 720–750 nm (d) None of these

64. Which is incorrect for bacterial photosynthesis?
(a) Utilize longer wave length of light
(b) H_2O is not utilized
(c) Only one pigment system
[✓ (d) Photoreductant is $NADPH_2$]

65. Which is the iron bacteria?
(a) *Nitrobacter* (b) *Bacillus pentotrophous*
(c) *Cladothrix* [✓ (d) *Beggiatoa*]

66. Chemosynthesis occurs in:
(a) Presence of light (b) Presence of O_2
(c) Absence of O_2 (d) None of these

67. Photosynthesis is a process in which:
(a) Light energy converts into chemical energy
(b) Creates useful energy
(c) Fixes CO_2 into carbohydrates
(d) Reverses the action of respiration

68. The specific function of light energy in the process of photosynthesis is to:
[✓ (a) Activate chlorophyll] (b) Split water
(c) Reduce CO_2 (d) Synthesize glucose

*69. Dry weight of green leaves will be:
(a) Greater in morning
(b) Almost same throughout the day
[✓ (c) Greater in late afternoon]
(d) None of the above

70. Quantasome contains:
(a) 200 chlorophyll molecules
(b) 230 chlorophyll molecules
(c) 250 chlorophyll molecules
(d) 300 chlorophyll molecules

71. The conversion of glycolate into CO_2 without production of ATP and $NADH_2$ is referred to as: **(AMU 1993)**
(a) Photophosphorylation
(b) Photorespiration
(c) Oxidative phosphorylation
(d) None of the above

72. Which is not chemosynthetic bacteria?
(a) *Nitrosomonas* (b) *Nitrobacter*
(c) *Beggiatoa* (d) *Azotobacter*

73. Water soluble pigment is:
(a) Chlorophyll (b) Carotene
(c) Xanthophyll (d) Phycobilin

74. During day light hours, the rate of photosynthesis is higher than that of respiration and the ratio of O_2 produced to consumed is:
(a) 1 : 1 (b) 10 : 1
(c) 50 : 1 (d) 5 : 1

75. Most effective converter of sunlight is:
(a) Rice [✓ (b) Sugar cane]
(c) Wheat (d) Papaya

76. Energy produced per gram is:
(a) Highest in case of wheat starch
(b) Highest in case of rice starch
(c) Highest in case of potato starch
(d) Same in all cases

77. Which pigment is absent in chloroplast?
(a) Chlorophyll–a (b) Carotene
(c) Anthocyanin (d) Xanthophyll

78. The first step in photosynthesis is:
(a) Joining of 3-C atoms to form glucose
(b) Formation of ATP
(c) Ionization of H_2O
(d) Excitement of an electron or Chl.–a by a photon of light

79. Leaves with yellow or colourless patches are known as:
(a) Etiolated [✓ (b) Variegated]
(c) Decolourized (d) None of these

80. Saussure discovered:
(a) Use of H_2O in photosynthesis
(b) Use of CO_2 in photosynthesis
(c) Use of chlorophyll in photosynthesis
(d) None of the above

81. Photosynthesis is mainly responsible for the existence of: **(CET Karnataka 1993)**
(a) Animals on this earth
(b) Plants on this earth
[✓ (c) Both plants and animals]
(d) None of the above

82. The most important reaction (phenomenon) in the universe is: **(CPMT 1992)**
[✓ (a) Photosynthesis] (b) Cation exchange
(c) Reduction (d) Carbonation

83. In photosynthesis, light:
(a) Is converted into kinetic energy
(b) Is converted into chemical energy
(c) Acts directly on CO_2 and water
(d) Acts like a catalyst

84. Total amount of the dry weight of photosynthate produced by all types of plants per annum is: (AMU 1992)
(a) 1·7 million tonnes
(b) 17 million tonnes
(c) 170 million tonnes
(d) 1700 million tonnes

85. The exact mechanism of photosynthesis is a process of converting light energy into chemical energy was established by: (CPMT 1991)
(a) Jean Senebier
(b) Robert Hill
(c) Ingenhousz
(d) None of these

*86. Two pigments common in all groups of algae are:
(a) Chlorophyll–a and b
(b) Chlorophyll–b and phycocyanin
(c) Phycocyanin and carotene
(d) Carotene and chlorophyll–a

87. The percentage of light energy fixed in photosynthesis is generally around: (CPMT 1991)
(a) 50
(b) 3
(c) 10
(d) 1

88. Light energy is used for activation of: (CPMT 1993)
(a) Chlorophyll molecule
(b) FAD
(c) NAD
(d) Cytochrome

89. Light energy is converted into chemical energy in the presence of: (MPPMT 1992)
(a) Pyrenoid
(b) Chloroplast
(c) Ribosomes
(d) Mesosomes

90. The process in which carbohydrates are synthesized by green plants from carbon dioxide and water in presence of light is known as:
(a) Respiration
(b) Photosynthesis
(c) Transpiration
(d) Absorption

91. Source of energy for carbon assimilation is:
(a) Chlorophyll
(b) CO_2
(c) Water
(d) Sunlight

*92. The smallest known plant having the same pigments as grasses and trees, belongs to:
(a) Chlorophyceae
(b) Schizomycetes
(c) Bryophyta
(d) Angiosperms

93. Chlorophyll–b is present in:
(a) Eukaryotes
(b) Prokaryotes
(c) Both prokaryotes and eukaryotes
(d) Bacteria

94. Photophosphorylation means synthesis of: (MPPMT 1996)
(a) ATP from ADP
(b) NADP
(c) ADP from ATP
(d) PGA

95. Kranz anatomy is typical of: (CBSE 1990)
(a) Hydrophytes
(b) C_3 plants
(c) C_4 plants
(d) CAM plants

96. During light reaction of photosynthesis which of the following phenomenon is observed during cyclic photophosphorylation as well as non – cyclic photophosphorylation? (CBSE 1994)
(a) Formation of ATP
(b) Release of O_2
(c) Involvement of both pigment system-I and pigment system-II
(d) Formation of $NADPH_2$

97. Major absorption band for phycocyanin is:
(a) 480–520 nm
(b) 555–565 nm
(c) 670–700 nm
(d) 610-625 nm

98. The ultimate biological energy comes from:
(a) Mitochondria
(b) Sunlight
(c) Glucose
(d) ATP

99. The correct molecular formula of chlorophyll–a is: (MPPMT 1991)
(a) $C_{55}H_{70}O_5N_4Mg$
(b) $C_{55}H_{72}O_6N_4Mg$
(c) $C_{55}H_{70}O_6N_4Mg$
(d) $C_{55}H_{72}O_5N_4Mg$

100. The process of taking in CO_2 by plants and releasing O_2 is termed as:
(a) Endosmosis
(b) Photosynthesis
(c) Transpiration
(d) Respiration

101. Photosynthesis is the conversion of light energy into chemical energy within a plant was first stated by:
(a) Willstatter and Stoll
(b) Mayer and Anderson
(c) Benson and Calvin
(d) Robert Mayer

102. When light is passed through a solution of chlorophyll in alcohol and then allowed to fall upon a glass, the spectrum is different from the spectrum of white light and shows the chlorophyll has absorbed certain colours. These colours are:
(a) Much of red and blue
(b) Much of yellow and blue
(c) Much of green and blue
(d) Much of green and orange

103. After absorption of radiant energy by pigment system-I, electron is released by: (MPPMT 1991)
(a) Chl-683
(b) Chl-673
(c) Chl-695
(d) P-700

104. The bulk fixation of carbon through photosynthesis takes place in: (CBSE 1994)
(a) Oceans
(b) Tropical rain forests
(c) Tropical rain forests and crop plants
(d) All crop plants

105. Basic structure of all chlorophylls comprises:
(a) Cytochrome system
(b) Flavoproteins
(c) Porphyrin system
(d) Plastocyanin

106. In a chlorophyll molecule, the magnesium is situated in the:
(a) Centre of porphyrin
(b) Corners of porphyrin
(c) Phytol chambers
(d) Isocyclic ring

107. The unit of photosynthesis is:
(a) Quantasome (b) Angstrom
(c) Geotropism (d) None of these

108. Chlorophyll absorbs:
(a) Red light only
(b) Blue light only
(c) Blue as well as red light
(d) Green light

109. The path of CO_2 in the dark reaction of photosynthesis was successfully traced by the use of following: (CPMT 1990; BHU 1992)
(a) $^{18}O_2$ (b) $^{14}CO_2$
(c) ^{32}P (d) X-ray

110. Solar energy is converted into ATP in: (CPMT 1990)
(a) Mitochondria [✓ (b) Chloroplast]
(c) Ribosomes (d) Peroxisomes

111. Blackman demonstrated that increasing illumination increased the photosynthetic rate upto a point when CO_2 became limiting. If light was not limiting, temperature becomes limiting. Emerson showed that maximum CO_2 fixation could be achieved with brief flashes of light. Mark the correct statement in the following:
(a) Only one factor can be limiting in photosynthesis
[✓ (b) Photosynthesis consists of a light and dark reaction]
(c) The trapping of light by chloroplast is temperature dependent
(d) The trapping of light by chloroplast can occur only if CO_2 is present

112. The colour of the rose petals is due to water soluble pigments present in the: (MPPMT 1992)
(a) Cytoplasm (b) Nucleus
(c) Intercellular space (d) Vacuoles

113. Discovery of "Emerson effect" has shown the existence of:
(a) Light and dark reaction in photosynthesis
(b) Two distinct photochemical reactions
(c) Photorespiration
(d) Photophosphorylation

114. Who received Nobel Prize for working out the early carbon pathway of photosynthesis? (BHU 1990)
(a) Calvin (b) Krebs
(c) Khorana (d) Watson

115. Chlorophyll is present: (AFMC 1992)
(a) In all higher plants [✓ (b) In all plants]
(c) In all lower plants (d) In fungi

116. Which of the following techniques has been most useful for investigating Calvin cycle? (CBSE 1991)
(a) Flash light experiment
(b) Radioactive isotope technique
(c) X-rays technique
(d) None of the above

117. The isotope of carbon used extensively for studies in photosynthesis is:
(a) C^{13} (b) C^{14}
(c) C^{15} (d) C^{16}

118. For chlorophyll formation in plants, elements needed are:
(a) Sodium and copper (b) Calcium and potassium
(c) Iron and magnesium (d) Iron and calcium

119. Photo-oxidation of water in photosynthesis is in association of: (BHU 1992)
(a) Cytochrome b_6 (b) Pigment system-I
(c) Pigment system-II (d) Plastocyanin

120. The role of chlorophyll in photosynthesis is:
(a) Absorption of CO_2
(b) Absorption of light
[✓ (c) Absorption of light and photochemical decomposition of water]
(d) Absorption of water

121. In the process of photosynthesis chlorophyll is:
(a) A raw material (b) A hydrogen acceptor
(c) An end product [✓ (d) An energy converter]

122. The absorption of radiant energy from sun is mainly associated with:
(a) Ribosomes (b) Mitochondria
[✓ (c) Chloroplasts] (d) Cytoplasm

123. In angiosperms, synthesis of chlorophyll occurs in presence of:
(a) Phytochrome (b) Light
(c) Cytochrome (d) None of these

124. Chloroplasts fix:
(a) O_2 (b) H_2
[✓ (c) CO_2] (d) N_2

125. Which colour of light gives maximum absorption peak by chlorophyll–a?
(a) Yellow (b) Red
(c) Blue (d) Green

126. The main difference between chlorophyll–a and b is: (AFMC 1993)
(a) Chlorophyll–a is a linear chain compound and b is branched chain
(b) Chlorophyll–a has no Mg^+ ion in centre of molecule
(c) In chlorophyll–a there is —CH_3 group whereas in b it is —CHO group
(d) All of the above

127. Chlorophyll is present:
(a) In grana of chloroplast
(b) On the surface of chloroplast
(c) Dispersed through the chloroplast
[✓ (d) In the stroma of chloroplast]

128. During photochemical reaction of photosynthesis:
[✓ (a) Liberation of O_2 takes place]
(b) Formation of ATP and $NADPH_2$ takes place
(c) Liberation of O_2 and formation of $NADPH_2$ takes place
(d) Assimilation of CO_2 takes place

129. These are the two types of photosynthetic pigments: (CET Karnataka 1993)
[✓ (a) Chlorophyll–a and chlorophyll–b]
(b) Chlorophyll–a, b and carotenoids
(c) Chlorophyll–a and carotenoids
(d) Chlorophyll–b and carotenoids

130. The wavelength of green light is:
(a) 400 – 450 mμ (b) 500 – 530 mμ
(c) 660 – 720 mμ (d) 720 – 800 mμ

131. Two pigment system theory of photosynthesis was proposed by:
(a) Hill (b) Emerson
(c) Blackman (d) Hatch and Slack

132. Chloroplast contains maximum quantity of:
(a) Pyruvic carboxylase (b) Hexokinase
(c) RuDP carboxylase (d) None of these

133. Which of the following occurs during dark phase of photosynthesis?
(a) Hydrogen is released
(b) ATP is produced
(c) Molecular oxygen is released
(d) PGAL is synthesized

134. During photosynthesis, when PGA is changed into phosphoglyceraldehyde which of the following reaction occurs?
(a) Oxidation (b) Hydrolysis
(c) Electrolysis (d) Reduction

135. In the process of photosynthesis the first visible product is :
(a) Starch (b) Glucose
(c) Fructose (d) Sucrose

136. During dark reactions of photosynthesis:
(a) 6 C sugar is broken down into 3C sugar
(b) Water is split
(c) CO_2 is reduced to organic compounds
(d) Chlorophyll is activated

137. CO_2 is necessary for photosynthesis; the chemical used to remove this gas most effectively from entering a control apparatus is:
(a) Calcium oxide
(b) Distilled water
(c) Sodium carbonate
(d) Potassium hydroxide solution

138. Carbon dioxide acceptor in C_3 plants is:
(a) Phosphoglyceric acid (PGA)
(b) Ribulose monophosphate (RMP)
[✓ (c) Ribulose 1, 5 diphosphate (RuDP)]
(d) Phospho-enol pyruvate (PEP)

139. The initial enzyme of Calvin cycle is: **(BHU 1990)**
[✓ (a) Ribulose 1, 5-diphosphate carboxylase]
(b) Triose-phosphate dehydrogenase
(c) Phosphopentokinase
(d) Cytochrome oxidase

140. The 'Dark reaction' in photosynthesis is called so because it:
(a) Can occur more rapidly at night
[✓ (b) Does not require light energy]
(c) Cannot occur during day time
(d) Can occur only in shade

141. The first product of photosynthesis in C_3 plant is: **(CPMT 1990)**
[✓ (a) 3-Phosphoglyceric acid]
(b) Dihydroxy acetone phosphate
(c) Fructose 1, 6-diphosphate
(d) Ribulose diphosphate and phosphoglyceraldehyde

142. In C_4 plants Calvin cycle:
(a) Occurs in stroma of bundle sheath chloroplasts
(b) Occurs in mesophyll chloroplasts
(c) Occurs in grana of bundle sheath chloroplasts
(d) Does not occur as CO_2 is fixed mainly by PEP and no CO_2 is left for Calvin cycle

143. Photosynthesis consists of essentially two biological reaction systems one followed by the other. The second of these systems does which of the following:
(a) Traps light energy
(b) Synthesizes starch
[✓ (c) Fixes carbon dioxide]
(d) Works only in the presence of light

144. Photosynthesis is more active in:
(a) Green light (b) Red light
(c) Yellow light [✓ (d) Sunlight]

145. Calvin cycle occurs in:
(a) Cytoplasm [✓ (b) Chloroplast]
(c) Glyoxysomes (d) Mitochondria

146. CO_2 joins the photosynthetic pathway during:
(a) Light reaction [✓ (b) Dark reaction]
(c) Photosystem-I (d) Photosystem-II

147. Ribulose diphosphate carboxylase oxygenase is located in: **(BHU 1989)**
(a) Mitochondria (b) Golgi bodies
(c) Peroxisomes (d) Chloroplast

148. The gas absorbed during photosynthesis is: **(CPMT 1986)**
(a) Oxygen (b) Nitrogen
(c) Ammonia (d) Carbon dioxide

149. Ferredoxin is a component of: **(CBSE 1991)**
(a) Hill reaction (b) Photosystem–I
(c) P–680 (d) Photosystem–II

150. Which is the evidence to show that O_2 released in photosynthesis comes from water? **(CPMT 1988)**
[✓ (a) Isotopic O_2 supplied as H_2O appears in the O_2 released in photosynthesis]
(b) Isolated chloroplast in water releases O_2 if supplied potassium ferrocyanide or some other reducing agent
(c) Photosynthetic bacteria use H_2S and CO_2 to make carbohydrates, H_2O and sulphur
(d) All of the above

*151. The red drop phenomenon is due to the disruption of the photochemical activity of: **(AIIMS 1988)**
(a) PS–I (b) Both PS–I and II
(c) PS–II (d) Carotenoids

152. In bacterial photosynthesis hydrogen donor is:
[✓ (a) H_2S] (b) NH_2
(c) H_2O (d) H_2SO_4

153. Bacterial photosynthesis involves:
[✓ (a) PS–I only] (b) PS–II only
(c) Both PS–I and PS–II (d) None of these

154. Besides water and light, which is more essential as a raw material for food formations :
(a) O_2 (b) CO_2
(c) Mineral salts (d) NAD

155. When a cell transfers light energy into chemical energy which of the following reaction would take place:
(a) ATP − IP = ADP (b) ADP + IP = ATP
(c) GDP + P = GTP (d) AMP + IP = ADP

156. Pigment system is concerned with:
(a) Photolysis of water (b) Reduction of CO_2
(c) Flowering (d) None of these

157. Radiant energy is stored in the form of chemical energy in:
(a) ATP (b) Stored food
(c) RNA (d) DNA

158. During ATP synthesis, electrons pass through:
(a) Water (b) Cytochromes
(c) O_2 (d) CO_2

***159.** Which element helps in the transport of electrons from water in photosynthesis?
(a) Na and K (b) Mo
(c) B (d) Mn and Cl

160. The electrons excited from pigment system-II pass directly to: **(Raj. PMT 1992)**
(a) Ferridoxin (b) Plastocyanin
(c) Plastoquinone (d) Carotenoids

161. In pigment system–I active chlorophyll is:
(a) P-600 (b) P-680
(c) P-700 (d) P-720

162. Which one is the precursor of chlorophyll? **(DPMT 1985)**
(a) Tryptophan
(b) Protochlorophyll or chlorophyllides
(c) Bacteriochlorophyll
(d) Bacterioviridin

163. In photosynthesis, in chloroplast dark reaction occurs in: **(CPMT 1990; CBSE 1991)**
(a) Grana lamellae (b) Stroma
(c) Stroma lamellae (d) Thylakoids

164. For photosynthesis, the green plants need only:
(a) Light (b) Chlorophyll
(c) CO_2 and water (d) All of these

165. Ribulose diphosphate carboxylase enzyme catalyses the reaction between:
(a) CO_2 and ribulose 1, 5 diphosphate
(b) Oxaloacetic acid and acetyl CoA
(c) PGA and dihydroxy acetone phosphate
(d) Ribulose diphosphate and phosphoglyceraldehyde

***166.** Bacteriochlorophyll differs from chlorophyll–a in having: **(CPMT 1989)**
(a) One pyrrole nucleus with one hydrogen
(b) One pyrrole nucleus with two hydrogen
(c) One pyrrole nucleus with three hydrogen
(d) One pyrrole nucleus with four hydrogen

167. The synthesis of ATP in photosynthesis and respiration is essentially an oxidation-reduction process involving removal of energy from: **(CBSE 1992)**
(a) Oxygen (b) Phytochrome
(c) Cytochrome (d) Electrons

168. CO_2 in the atmosphere remains relatively constan because: **(APMEE 1985**
(a) CO_2 is converted into carbohydrate during photo synthesis
(b) CO_2 is converted into $CaCO_3$
(c) Bacteria use up CO_2
(d) CO_2 is released during respiration and is used up ir photosynthesis

169. Which one is produced during cyclic photophosphorylation? **[BCECE (P.T. Exam.) 2001]**
(a) ATP and $NADPH_2$ (b) ATP and O_2
(c) $NADPH_2$ only (d) ATP only

***170.** Which of the following photosynthetic bacteria have both PS–I and PS–II? **(CPMT 1990)**
(a) Green sulphur bacteria
(b) Purple-sulphur bacteria
(c) Purple non-sulphur bacteria
(d) Cyanobacteria

171. During the course of photosynthesis:
(a) ATP is formed
(b) ATP is not formed
(c) Oxygen evolved comes from carbon dioxide
(d) Water is required as medium but it does not take part in photosynthetic reactions

172. Photosystem occurs in: **(CBSE 1992)**
(a) Stroma
(b) Grana
(c) On surface of mitochondria
(d) On cytochrome

173. ATP formation during photosynthesis is known as:
(a) Oxidative phosphorylation
(b) Phosphorylation
(c) Photophosphorylation
(d) None of the above

174. Which of the following is a Hill's reaction?
(a) Photolysis of water by isolated chloroplasts resulting in the formation of $NADPH_2$ and ATP
(b) Photolysis of water by isolated chloroplasts in light resulting in the reduction of some chemical compounds and release of oxygen
(c) Photolysis of water releasing oxygen and hydrogen by isolated chloroplasts in the presence of light
(d) Photolysis of water by chloroplasts

175. The suspension of isolated thylakoids in culture medium containing CO_2 and H_2O does not produce hexose because:
(a) Light trapping device is not functional
(b) Enzymes are absent
(c) CO_2 assimilation does not occur
(d) PS–I and PS-II are not linked

176. The concept of two photosystems participating in light reaction of photosynthesis was given by:
(a) D.I. Arnon (b) F.F. Blackman
(c) R. Hill (d) Robert Emerson

177. In blue-green algae Photosystem–II contains an important pigment concerned with photolysis of water. It is called:
(a) β-carotene (b) Chlorophyll-b
(c) Cytochrome–c (d) Phycocyanin

178. The trapping centre of light energy in photosystem-I is:
(a) P–660 (b) P–700
(c) P–720 (d) P–680

179. The range of visible spectrum, which is suited best for photosynthesis: **(BHU 1994)**
(a) 300–400 nm
(b) 400–500 nm
(c) 600–700 nm
(d) 660–700 nm and 400–500 nm

180. Which of the following is least effective in photosynthesis?
(a) Green light (b) Red light
(c) Sunlight (d) Blue light

181. Moll's experiment shows:
(a) CO_2 is essential for photosynthesis
(b) Chlorophyll is essential for photosynthesis
(c) Unequal transpiration from two surfaces of a leaflet
(d) Relation between transpiration and absorption

182. Which of the following is not required in the synthesis of carbohydrates?
(a) CO_2 (b) Chlorophyll
(c) Nitrogen (d) Water

183. The process of photosynthesis takes place in:
(a) Roots only
(b) Shoot only
(c) All the cells of the plant
(d) Chlorophyll containing cells only

184. In a photosynthesis experiment, plant growth could be best when exposed to?
(a) Yellow and orange lights
(b) Blue and green lights
(c) Red and blue lights
(d) Green light

185. Which of the following proves that CO_2 is essential for photosynthesis?
(a) Calvin's experiment (b) Moll's experiment
(c) Hill's experiment (d) Arnon's experiment

186. Which one of the following would not be a limiting factor for photosynthesis?
(a) Oxygen (b) Light
(c) Carbon dioxide (d) Chlorophyll

187. Starch is detected in food by its:
(a) Blue reaction with iodine solution
(b) Granular form even if cooked
(c) Presence of an energy store
(d) White appearance

***188.** The energy wastage occurs during:
(a) Dark reaction (b) Photorespiration
(c) Photosynthesis (d) None of these

189. The experimental material which helped advances in photosynthesis research is:
(a) Spinach leaves (b) *Chlamydomonas*
(c) *Hydrilla* (d) *Chlorella*

190. Rate of photosynthesis is independent of:
(a) Temperature (b) Quality of light
(c) Duration of light (d) Intensity of light

191. It is appropriate that *Chlorella* (an alga) is taken for photosynthesis experiment instead of land plant because:
(a) It respires slowly
(b) It does not transpire
(c) Oxygen coming out from it can be collected on water
(d) It photosynthesizes at a faster rate

192. Q_{10} is defined as:
(a) Temperature coefficient
(b) Scale of light quality
(c) Respiratory coefficient
(d) Constant quantam equation

193. It is advantageous to use *Hydrilla* to demonstrate photosynthesis than land plant because:
(a) It respires slowly
(b) It does not transpire
(c) It photosynthesizes rapidly
(d) Oxygen bubbles can be collected over water

194. The law of limiting factors in photosynthesis was enunciated by: **(BHU 1997; CPMT 2002)**
(a) R. Hill (b) Calvin
(c) Blackman (d) Krebs
(e) Arnon

***195.** As there is only 0·03% of CO_2 in the atmosphere and when the green plants on the earth use CO_2 every year, there is danger of scarcity of CO_2 in:
(a) 100 years (b) About 1000 years
(c) After 3000 years (d) No danger at all

196. Decreased rate of photosynthesis at high concentration of oxygen is referred to as:
(a) Pasteur effect (b) Emerson effect
(c) Warburg effect (d) Richmond-Lang effect

***197.** If CO_2 content of the atmosphere is as high as 300 parts per million:
(a) The plants would not grow properly
(b) The plants would thrive well
(c) All plants would be killed
(d) Plants would grow for sometime then die

198. Dark reaction is known as: **(CPMT 1993)**
(a) Cyclic reaction (b) Calvin cycle
(c) Non cyclic reaction (d) Hill reaction

199. If the range of day light of a bright sunny day is increased, the rate of photosynthesis: **(Raj. PMT 1992)**
(a) Increase (b) Decrease
(c) Remains unchanged (d) Cannot be predicted

200. The C_4 plants are different from C_3 plants with reference to the:
(a) Type of pigment involved in photosynthesis
(b) Type of end products of photosynthesis
(c) Number of ATP that are consumed in preparing sugars
(d) Substrate that accepts CO_2 in carbon assimilation

201. C_4 plants are adapted to:
   - (a) Hot and dry climate
   - (b) Temperate climate
   - (c) Cold and dry climate
   - (d) Hot and humid climate

202. The role of chlorophyll in photosynthesis is as a:
   - (a) Reactant or H_2 acceptor
   - (b) Raw material
   - (c) Catalyst
   - (d) Energy entraper and converter

203. In a fish aquarium, green aquatic plants are grown primarily for:
   - (a) Decoration (b) Fish food
   - (c) O_2 (d) CO_2

204. In C_4 plants, carbon dioxide is first fixed in:
   - (a) Bundle sheath (b) Mesophyll
   - (c) Palisade parenchyma (d) Spongy parenchyma

205. In C_4 cycle, CO_2 is fixed by: **(CBSE 1992)**
   - (a) Phosphoglycolic acid
   - (b) Phospho-enol pyruvate (PEP)
   - (c) Oxaloacetic acid
   - (d) RuBP

206. Glycolate accumulates in chloroplast at: **(CPMT 1991)**
   - (a) Low temperature (b) Low CO_2
   - (c) Bright illumination (d) High CO_2

207. Substrate for photorespiration is:
   - (a) Serine (b) Glycolic acid or glycolate
   - (c) Indole acetic acid (d) Malic acid

208. Kranz type of anatomy is found in: **(CBSE 1990)**
   - (a) C_2 plants (b) C_3 plants
   - (c) C_4 plants (d) C_6 plants

209. C_4 cycle was discovered by: **(BHU 1991; CPMT 1993)**
   - (a) Hill (b) Arnon
   - (c) Hatch and Slack (d) Calvin

210. The first stable product in mesophyll cells cycle is: **(CPMT 1992)**
   - (a) Phosphoglyceraldehyde
   - (b) Phosphoglyceric acid
   - (c) Phospho-enol pyruvic acid
   - (d) None of the above

*211. Which one of the following crop plants is very efficient converter of solar energy and whose net productivity value ranges from 2 kg to 4 kg/m^2 or even higher:
   - (a) Sugar cane (b) Rice
   - (c) Wheat (d) Bajra

212. C_4 plants are found among: **(BHU 1990)**
   - (a) Gramineae Only
   - (b) Monocots only
   - (c) Dicots only
   - (d) Monocots as well as dicots

213. The first product of CO_2 fixation in Hatch and slack's pathway in plants is:
   - (a) Formation of oxaloacetate by carboxylation of phospho-enol pyruvate (PEP) in the bundle sheath cells
   - (b) Formation of oxaloacetate by the carboxylation of phospho-enol pyruvate (PEP) in mesophyll cells
   - (c) Formation of phosphoglyceric acid in the mesophyll cells
   - (d) Formation of phosphoglyceric acid in the bundle sheath cells

214. Algae float in water during day time and sink during night time because:
   - (a) They become light due to consumption of food material in respiration
   - (b) They become buoyant in light due to accumulation of oxygen bubbles released in photosynthesis
   - (c) They come upto enjoy sun shine
   - (d) They loose weight at night

215. Which is the first stable product of CO_2 fixation? **(MPPMT 1993)**
   - (a) Ribulose phosphate (b) PGAL
   - (c) Glucose (d) Starch

216. The sequential energy changes in photosynthesis are:
   - (a) Electrical → Chemical
   - (b) Light → Chemical
   - (c) Light → Electrical → Chemical
   - (d) Chemical → Light → Electrical

217. CO_2 is formed in all the following except:
   - (a) Burning of sugar
   - (b) Respiration in plants
   - (c) Photosynthesis by plants
   - (d) On heating of limestone

218. C_4 photosynthetic pathway is met within: **(CBSE 1993; St. Johns 2002)**
   - (a) Corn (b) Potato
   - (c) Mustard (d) Water hyacinth

219. PS–II system is concerned with: **(CPMT 1993)**
   - (a) Photolysis of water (b) Release of energy
   - (c) Reduction of CO_2 (d) Formation of H_2O

220. CAM photosynthesis occurs in plants with: **(MPPMT 1993)**
   - (a) Thin green leaves with reticulate venation
   - (b) Thin green leaves with parallel venation
   - (c) Fleshy green leaves
   - (d) Thin coloured leaves

*221. In blue-green algae, the PS–II contains an important pigment concerned with photolysis of water:
   - (a) β-carotene (b) Chlorophyll
   - (c) Cytochrome (d) Phycocyanin

222. For the process of photosynthesis all except–one of the following items are essential, point out the exception:
   - (a) Water, mineral
   - (b) Light, chlorophyll
   - (c) Carbon dioxide, optimum temperature
   - (d) Oxygen, sucrose

223. Photosynthesis consists of essentially two biological reaction systems, one followed by the other. The second of these systems does which of the following?
   - (a) Traps light-energy
   - (b) Synthesizes starch

(c) Fixes carbon dioxide
(d) Works only in the presence of light

*224. In photosynthesis hydrogen is transferred from the 'light' reactions to the 'dark' reactions by:
(a) DPN (b) DNA
(c) ATP (d) NADP

225. Which of the following technique in addition to radioactive tracer technique was employed by Calvin to find the path of carbon in photosynthesis? (MPPMT 1991)
(a) Chromatography (b) Electrophoresis
(c) Spectrophotometry (d) Histochemistry

226. The herbicide DCMU kills weeds because it:
(a) Inhibits respiration (b) Inhibits CO_2 fixation
(c) Inhibits cell division (d) Inhibits NO_3 uptake
(CPMT 1992)

227. In dark reactions:

$$6CO_2 + A + 12NADPH + H^+ \rightarrow C_6H_{12}O_6 + 6H_2O + B + 18H_3PO_4 + 12NADP$$

A and B are respectively:
(a) 6 ATP and 6 ADP (b) 6 ADP and 6 ATP
(c) 18 ADP and 18 ATP (d) 18 ATP and 18 ADP

228. The starch present in the tissues of a bean plant has been:
(a) Absorbed from the soil through root hair
(b) Produced as a by-product of respiration
(c) Secreted from the cell walls
(d) Synthesized from glucose in the cells

229. Two plants are thought to be taxonomically closely related, if:
(a) They store carbohydrates in the same kind of molecule
(b) Both have pinnately veined leaves
(c) Both obtain energy by changing ATP to ADP + Pi
(d) Each builds antibodies to few, if any of the others proteins

230. Englemann (1882) observed that motile aerobic bacteria accumulated near areas of a filament of *Spirogyra* which were illuminated by red or blue light but they did not accumulate near a filament illuminated with green light. From this, he inferred that:
(a) Chlorophyll absorbs green light.
(b) O_2 is released from CO_2 in the light reaction
(c) O_2 is released from H_2O in the light reaction
(d) Red and blue light are more effective in photosynthesis

231. The branched pattern of stem growth characteristic of larger photosynthetic plant is an adaptation which:
(a) Distributes weight most efficiently
(b) Permits survival during periods of dry weather
(c) Allows water to circulate in stem most easily
(d) Provides maximum exposure of leaves to light

232. The wave length of light to carry out photosynthesis in bacteria is:
(a) Ultraviolet (b) blue
(c) Red (d) Far red

233. If CO_2 is given off in respiration, why does the amount of CO_2 in the atmosphere remains relatively constant:
(a) CO_2 forms carbonate rocks
(b) CO_2 is a buffer
(c) CO_2 is converted in photosynthesis to carbohydrates
(d) CO_2 is split up during photosynthesis

234. Calvin exposed *Chlorella* cells to $C^{14}O_2$ and light for a fraction of a second. The C^{14} appeared in a 3-carbon compound. A shorter exposure showed the C^{14} in a 5 carbon compound. A longer exposure showed the C^{14} in a 6 carbon compound and in starch. This suggests that:
(a) A 6-carbon compound is synthesized from a 5-carbon compound which comes from a 4-carbon compound
(b) The 5-carbon compound is broken down from a 6-carbon compound which is synthesized from two 3-carbon compounds
(c) CO_2 is added to a 5-carbon compound forming a 6-carbon compound which is split up
(d) Starch is the end product of photosynthesis

235. Which one of the following is needed in both photosynthesis and respiration? (MPPMT 1996)
(a) Sunlight (b) Chlorophyll
(c) Glucose (d) Cytochrome

*236. Name the enzyme which changes its characteristics with change in concentration of O_2?
(a) RuBP carboxylase (b) PEP
(c) PGA (d) None of these

237. The first CO_2 acceptor in C_4 plants is:
(MPPMT 1996; CPMT 1997)
(a) PEPA (b) RuDP
(c) PGA (d) OAA

238. The excess energy of electron is used in the synthesis of:
(a) Organic compounds (b) ATP from ADP and Pi
(c) $NADPH_2$ from NADP (d) None of these

239. Photosynthesis does not take place during the night because:
(a) Optimum temperature is not available at night
(b) Light is not available at night
(c) Concentration of oxygen is less in the atmosphere
(d) More carbon dioxide is evolved at night which inhibits the action of enzymes

240. In C_4 plants initial CO_2 fixation takes place in the chloroplasts of: (CBSE 1995; MPPMT 1997)
(a) Guard cells (b) Mesophyll cells
(c) Spongy parenchyma (d) Bundle sheath

241. Action spectrum of photosynthesis was described in 1883 by:
(a) Robert Hill (b) M. Calvin
(c) T.W. Englemann (d) Hatch and Slack

242. How many ATP molecules are required by the C_4 plants for the synthesis of a glucose molecule?
(a) 30 ATP (b) 20 ATP
(c) 10 ATP (d) 1 ATP

243. The first and most important function of leaf is:
(a) To provide fodder (b) Interchange of gases
(c) Evaporation of water (d) Manufacture of food

244. Green plants can have photosynthesis when provided a wavelength upto:

(a) 440 nm (b) 660 nm
(c) 700 nm (d) 800 nm

245. Under electric light photosynthesis:
(a) Will occur
(b) Will not occur
(c) May occur in low intensity of light
(d) May occur in high intensity of light

246. During photosynthesis light is absorbed by:
(a) Photosystem–I
(b) Photosystem–II
(c) By both photosystem–I and II
(d) None of the above

247. In formation of 3–PGA in Calvin cycle, the source of carbon atoms is: (BHU 1994)
(a) RuBP only (b) RuBP + CO_2
(c) CO_2 only (d) RUBP + CO_2 + PEP

248. How many ATP molecules are needed for the regeneration of RuBP in the dark reaction?
(a) One molecule of ATP is required to regenerate one molecule of RuBP during the dark reaction
(b) Two molecules of ATP are required to regenerate one molecule of RuBP in dark reaction
(c) Four molecules of ATP are required to regenerate one molecule of RuBP in dark reaction
(d) None of the above

249. Which element is essential for photolysis of water? (MPPMT 1997)
(a) Nitrogen (b) Chlorine
(c) Carbon (d) Oxygen

250. Bubbles of gas generated by *Elodea* or *Spirogyra* are:
(a) Methane (b) Carbon dioxide
(c) Oxygen (d) Sulphur dioxide

251. Strongest band in the absorption spectrum in chlorophyll occurs in:
(a) Blue and violet (b) Green
(c) Far red (d) Red

*252. Agranal chloroplasts occur in certain:
(a) Succulents (b) C_4 plants
(c) Hydrophytes (d) C_3 plants

253. Who for the first time experimentally demonstrated that oxygen is evolved from water during photosynthesis? (MPPMT 1995)
(a) Calvin (b) Robert Hill
(c) Govindji (d) Ruben and Kamen

254. Chlorophyll–a molecule at its carbon atom third of the pyrole ring II has one the following: (CBSE 1996, 97)
(a) Aldehyde group (b) Carboxylic group
(c) Magnesium (d) Methyl group

255. Which one of the following is represented by Calvin cycle? (CBSE 1996)
(a) Oxidative carboxylation
(b) Phosphorylation
(c) Oxidative phosphorylation
(d) Reductive carboxylation

256. Chlorophyll is soluble in : (AIIMS 1996)
(a) Water
(b) Organic solvents
(c) Water and organic solvents
(d) Not in any solvent

257. What will be the number of turns of Calvin cycle generate one molecule of hexose sugar? (CBSE 19
(a) 4 (b) 6
(c) 8 (d) 9

258. Plants are known as purifiers of air due to process of: (AIIMS 19
(a) Respiration (b) Photosynthesis
(c) Transpiration (d) Desiccation

259. Chemosynthetic bacteria in place of water use other donc like H_2S as a source of hydrogen because: (BHU 199
(a) They cannot tolerate oxygen
(b) Other donors are easily available in the growi medium
(c) Other donors need less ATP
(d) All of the above

260. Which of the following statement is correct about C_4 typ of photosynthesis? (BHU 199
(a) C_4 cycle is an independent cycle.
(b) C_4 cycle is adjunct to Calvin cycle
(c) RuBP carboxylase has higher affinity for CO_2
(d) Carboxylase is present in the bundle sheath cells

261. Photo-oxidation refers to: (AMU 1996; AIIMS 1997
(a) Photorespiration
(b) Photolysis of water
(c) Light induced breakdown of a substance in th presence of oxygen
(d) All of the above

262. The chlorophyll molecule has a: (AMU 1996)
(a) Porphyrin head and phytol tail
(b) Phytol head and porphyrin tail
(c) Phosphate head and porphyrin tail
(d) All of the above

263. The most plants are green in colour because: (CBSE 1997)
(a) The atmosphere filters out all the colours of the visible light spectrum except green
(b) Green light is the most effective wave length-region of the visible spectrum is sunlight for photosynthesis
(c) Chlorophyll is least effective in absorbing green light
(d) Green light allows maximum photosynthesis

264. The two enzymes responsible for primary carboxylation in C_3 and C_4 plants respectively are: (AMU 1997)
(a) PEP carboxylase and RuBP carboxylase
(b) RuBP carboxylase and PEP carboxylase
(c) PEP carboxylase and pyruvate carboxylase
(d) RuBP carboxylase and pyruvate carboxylase

265. The electron energy transfer between acessory pigments and chlorophyll molecules takes place by: (AMU 1997)
(a) Radiation (b) Resonance
(c) Transduction (d) Flourescence

266. In which of the following plant types, both PEP carboxylase and RuBP carboxylase are present in the cell chloroplasts? **(Pondicherry 1996)**
(a) CAM (b) C_4
(c) C_3 (d) CAM and C_4

267. C_4 plants have higher net photosynthetic rate because: **(BHU 1996; Pb. PMT 1997)**
(a) They have no photorespiration
(b) They can photosynthesize in low light intensity
(c) They have PEP as CO_2 acceptor
(d) They have kranz type of anatomy

268. The correct statement is: **(Pondicherry 1997)**
(a) Thorns are endogenous in origin
(b) In a corymb all the flowers are seen to arise from the same point
(c) Thymine is a base of RNA
(d) C_4 plants possess kranz type of leaf anatomy

*269. Photosynthetic evolution of oxygen requires: **(Pondicherry 1996; Manipal 1997)**
(a) Co-enzyme (b) Fe-enzyme
(c) Mn-enzyme (d) Zn-enzyme

270. The isotopes that have proved useful in researches on photosynthesis are: **(Pondicherry 1996)**
(a) O^{18} and O^{14} (b) C^{11} and P^{32}
(c) C^{14} and O^{18} (d) P^{32} and O^{18}

271. Rubisco (RuBP– carboxylase oxygenase), a protein which comprises: **(AMU 1997)**
(a) 5% of the total chloroplast portion
(b) 11% of the total chloroplast portion
(c) 16% of the total chloroplast portion
(d) 20% of the total chloroplast portion

272. Photosynthetically active radiation is represented by the range of wavelength of: **(BHU 1995; CBSE 1996)**
(a) 340–450 nm (b) 400–700 nm
(c) 500–600 nm (d) 400–950 nm

273. The mechanism of ATP formation within chloroplast and mitochondria is explained by: **(CBSE 1997)**
(a) Relay pump hypothesis of Godlewski
(b) Munch's pressure mass flow hypothesis
(c) Chemiosmotic theory of Mitchell
(d) Cholodny Went's model

274. $NADPH_2$ is generated through: **(CBSE 1997)**
(a) Photosystem–I (b) Photosystem–II
(c) Anaerobic respiration (d) Glycolysis

275. PS-I and PS-II were discovered by: **(CPMT 1997)**
(a) Robert Emerson (b) Blackman
(c) Robert Mayer (d) Arnon

276. Enzymes for dark reaction are present in: **(CPMT 1997)**
(a) Mitochondria (b) Cytoplasm
(c) Nucleus (d) Stroma of chloroplast

277. Which range of light is absorbed maximum by green plants?
(a) 510–600 Å (b) 400–450 Å
(c) 700–800 Å (d) None of these

278. Kranz anatomy is found in: **(CPMT 1998)**
(a) Monocot (b) Dicot
(c) Gymnosperm (d) Fern

279. PEP is found in: **(CPMT 1998)**
(a) C_3 plants (b) C-4 plants
(c) Both (a) and (b) (d) All Plants

*280. C-4 plants require: **(CPMT 1998)**
(a) Lesser CO_2 (b) Lesser salts
(c) Lesser water (d) Lesser light

281. What happens in photosystem-II? **(AFMC 1998)**
(a) CO_2 fixation (b) CO_2 reduction
(c) Photolysis of H_2O (d) All of these

*282. Maximum CO_2 fixation is done by: **(CBSE 1999)**
(a) Green plants (b) Phytoplanktons
(c) Zooplanktons (d) Bacteria

283. CO_2 fixed annually through photosynthesis is about: **(CBSE 1999)**
(a) 4.6×10^{21} kg (b) 7.0×10^{13} kg
(c) 7.0×10^{20} kg (d) 4.6×10^{10} kg

284. Which enzyme is most abundantly found on earth? **(CBSE 1999)**
(a) Catalase (b) Invertase
(c) Nitrogenase (d) Rubisco

*285. Cyclic photophosphorylation occurs under which condition? **(CPMT 1999)**
(a) Anaerobic (b) Aerobic
(c) Both (a) and (b) (d) None of these

286. Copper containing pigment involved in photosynthesis is: **(CPMT 1999)**
(a) Cytochrome (b) Plastocyanin
(c) Ferridoxin (d) Chlorophyll

*287. Under normal field conditions, which one is the limiting factor in photosynthesis? **(CPMT 1999)**
(a) CO_2 (b) Light
(c) Water (d) None of these

288. For study of C-3 cycle, experiments were performed on: **(BHU 1999)**
(a) *Chlorella* (b) *Scenedesmus*
(c) Both (a) and (b) (d) None of these

289. Solarization means: **(BHU 1999)**
(a) Photo-oxidation of chlorophyll
(b) Increase in production of chlorophyll
(c) Increase in amount of cellular components
(d) None of the above

290. How many times the Calvin cycle occurs to produce two molecules of glucose? **(AIIMS 1999)**
(a) 1 (b) 2
(c) 6 (d) 12

291. Which pigment is present universally in all green plants? **(MPPMT 1999)**
(a) Chlorophyll-a (b) Chlorophyll-b
(c) Chlorophyll-c (d) Chlorophyll-m

292. Light reaction takes place in: **(MPPMT 1999)**
(a) Grana (b) Stroma
(c) Chloroplast membrane (d) Endoplasmic reticulum

293. Carbon dioxide is fixed in: **(MPPMT 1999)**

(a) Light reaction (b) Dark reaction

(c) Aerobic respiration (d) Anaerobic respiration

294. In photosynthesis, oxygen is liberated due to: **(MPPMT 1999)**

(a) Hydrolysis of carbohydrates

(b) Breakdown of proteins

(c) Photolysis (hydrolysis) of water

(d) Reduction of CO_2

295. First reaction of photosynthesis is: **(CBSE 2000; JIPMER 2002)**

(a) Photolysis of water (b) Excitation of electron

(c) Dark reaction (d) ATP formation

296. Number of ATP and $NADPH_2$ consumed during the fixation of one CO_2 molecule in Calvin cycle: **(CBSE 2000)**

(a) 3 ATP and 3 $NADPH_2$ (b) 3 ATP and 2 $NADPH_2$

(c) 2 ATP and 3 $NADPH_2$ (d) 18 ATP and 12 $NADPH_2$

297. How many times a Calvin cycle is repeated to form a glucose molecule? **(CBSE 2000)**

(a) Two (b) Four

(c) Six (d) Eight

298. In the dark phase of photosynthesis: **(AFMC 2000)**

(a) PGAL is formed (b) CO_2 is fixed

(c) ATP is consumed (d) All of these

299. Which of the following is a C-4 plant? **(MPPMT 2000; St. Johns 2002)**

(a) Sugar cane (b) Mango

(c) Apple (d) Tomato

300. Photosynthesis is most active in: **(MPPMT 2000)**

(a) Green light (b) Red light

(c) Yellow light (d) Violet light

301. Emerson effect is associated with: **(CET Karnataka 2000)**

(a) Respiration (b) Salt absorption

(c) Photosynthesis (d) Transpiration

302. CO_2 acceptor in C-4 plants is: **(BHU 2000; Orissa JEE 2002)**

(a) PGA (b) PEP

(c) RuBP (d) OAA

303. Photosystem-I and photosystem-II are found in: **(MPPMT 2001)**

(a) Stroma of chloroplast

(b) Grana of chloroplast

(c) Matrix of mitochondria

(d) Inner membrane of mitochondria

304. Blackman's law of limiting factor is applied to: **(AIIMS 2001)**

(a) Growth (b) Respiration

(c) Transpiration (d) Photosynthesis

305. Which pair is wrong? **(CBSE 2001)**

(a) C-3—Maize

(b) C-4—Kranz anatomy

(c) Calvin cycle—PGA

(d) Hatch and Slack's cycle—OAA

306. Which pigment system is inactivated in red drop? **(CBSE 2001)**

(a) PS-I and PS-II (b) PS-I

(c) PS-II (d) None of these

307. Which of the following is not a limiting factor for photosynthesis? **(Uttaranchal PMT 2001)**

(a) CO_2 (b) Light

(c) Chlorophyll (d) O_2

*308. PEPCO is associated with: **(Uttaranchal PMT 2001)**

(a) CAM plants (b) C-3 plants

(c) C-4 plants (d) None of these

309. The first stable product of photosynthesis in C-4 plant is: **(CET Karnataka 2001)**

(a) Ribulose 1,5-biphosphate

(b) Phosphoglyceric acid

(c) Malic acid

(d) PGAL

310. First transitory chemical formed by reaction between CO_2 and RuBP is: **(CET J&K 2002)**

(a) PGAL/GAP (b) DHAP

(c) 2-carboxy, 3-keto, 1,5-biphospho ribotol

(d) PGA

311. The process in which excess energy is lost by light waves is called: **(JIPMER 2002)**

(a) Fluorescence (b) Photophosphorylation

(c) Photolysis (d) Photooxidation

312. The electron transport chain of photosynthetic process is: **(JIPMER 2002)**

(a) In the stroma of chloroplast

(b) Bound to the thylakoid membranes

(c) Present in the outer membrane of chloroplast

(d) Present in mitochondria

313. Chlorophyll molecules are green in colour because they: **(CET Karnataka 2002)**

(a) Transform green light (b) Transmit green light

(c) Absorb green light (d) Reflect green light

314. Which of the following does not occur during light reaction? **(Raj. PMT 2001)**

(a) Electron transfer (b) Release of O_2

(c) Photolysis of H_2O (d) Release of H_2

315. The ions necessary for proper functioning of PS-II is: **(Raj. PMT 2001)**

(a) Mn^{2+} and Cl^- (b) Mg^{2+} and NO_3^-

(c) Fe^{2+} and Cl^- (d) K^+ and Na^+

316. In synthesis of glucose, hydrogen is taken from: **(Raj. PMT 2001)**

(a) H_2O (b) $NADPH_2$

(c) $FADH_2$ (d) $n(CH_2O)$

*317. What percentage of usable radiant energy entering a reaction site of photosynthesis is converted to potential energy? **(BHU 2002)**

(a) 10% (b) 20%

(c) 35% (d) 42%

318. C-4 plants have an advantage over C-3 plants when the weather is: (BHU 2002)
(a) Only hot (b) Hot and wet
(c) Hot and dry (d) Cold and dry

319. Which of the following absorb light energy for photosynthesis? (CBSE 2002)
(a) Chlorophyll (b) Water molecule
(c) O_2 (d) RuBP

320. In photosynthesis energy from light reaction to dark reaction is transferred in the form of: (CBSE 2002)
(a) ADP (b) ATP
(c) RuDP (d) Chlorophyll

*321. RuBP-oxygenase is present in: (St. Johns 2002)
(a) Golgi bodies (b) Peroxisome
(c) Chloroplast (d) Mitochondria

322. Oxygen produced in photosynthesis comes from H_2O was shown by: (St. Johns 2002)
(a) Robert Mayer (b) Ruben and Kamen
(c) Calvin (d) Robert Hill

323. Which of the following is needed both in photosynthesis and respiration? (EAMCET 2002)
(a) Chlorophyll (b) CO_2
(c) O_2 (d) Cytochromes

324. In photosynthetic electron transport system, manganese ions are associated with: (EAMCET 2002)
(a) Oxygen evolving complex
(b) $CF_0 - CF_1$ complex
(c) Cytochrome $b_6 -$ F complex
(d) Plastoquinones

325. Cu is present in: (CPMT 2003)
(a) Plasmalemma (b) Plastoquinone
(c) Plasto cyanin (d) Ferridoxin

326. In which of the following oxygen does not evolve during photosynthesis? (CPMT 2003)
(a) Photosynthetic red algae
(b) Photosynthetic green algae
(c) Photosynthetic blue green algae
(d) Photosynthetic bacteria

327. Which of the following is concerned with CO_2 fixation? (CPMT 2003)
(a) Krebs' cycle (b) Calvin cycle
(c) Ornithine cycle (d) Glycolysis

328. In photosynthesis there is: (CPMT 2003)
(a) Reduction of H_2O (b) Oxidation of H_2O
(c) Oxidation of CO_2 (d) Oxidation of NO_2

329. Rubisco is an enzyme for: (Orissa JEE 2003)
(a) CO_2 fixation in dark reaction
(b) Photorespiration
(c) Regeneration of RuBP
(d) Photolysis of water

330. Noncyclic photophosphorylation during photosynthesis produces: (Orissa JEE 2003)
(a) NADPH (b) NADP
(c) NADH (d) NAD

331. In presence of light, green plants convert carbondioxide and water into food stuffs. Which of the following is likely to be the first substance that a green plant makes in photosynthesis? (BV Pune 2003)
(a) Fat (b) Cellulose
(c) Starch (d) A simple sugar

332. Which of the following fixes CO_2 in carbohydrates? (BV Pune 2003)
(a) *Rhodospirillum* (b) *Nitrobacter*
(c) *Rhizobium* (d) *Bacillus*

333. The trapping centre of light energy in photosystem I is: (BV Pune 2003)
(a) P–720 (b) P–700
(c) P–680 (d) P–660

334. Autoradiography technique was used to: (BV Pune 2003)
(a) Find out the absorption maximum of chlorophyll pigments
(b) Study photorespiration in certain plants
(c) Establish that the oxygen evolved during photosynthesis is by photolysis of water molecules
(d) Trace the path of carbon in photosynthesis

335. Which of the following concerns photophosphorylation? (CBSE 2003)
(a) $\text{ADP} + \text{AMP} \xrightarrow{\text{Light energy}} \text{ATP}$
(b) $\text{ADP} + \text{inorganic } PO_4 \xrightarrow{\text{Light energy}} \text{ATP}$
(c) $\text{AMP} + \text{inorganic } PO_4 \xrightarrow{\text{Light energy}} \text{ATP}$
(d) $\text{ADP} + \text{inorganic } PO_4 \xrightarrow{\text{Light energy}} \text{ATP}$

*336. Which fractions of the visible spectrum of solar radiations are primarily absorbed by carotenoids of higher plants? (CBSE 2003)
(a) Green and red (b) Red and violet
(c) Violet and blue (d) Blue and green

ANSWERS

1—b	2—b	3—b	4—c	5—b	6—c	7—b	8—c	9—d	10—b	11—c	12—b
13—c	14—c	15—c	16—b	17—b	18—c	19—c	20—b	21—d	22—d	23—d	24—c
25—b	26—b	27—c	28—d	29—b	30—c	31—c	32—c	33—d	34—c	35—b	36—d
37—b	38—a	39—a	40—a	41—a	42—a	43—c	44—b	45—c	46—a	47—c	48—d
49—b	50—b	51—c	52—d	53—d	54—c	55—d	56—c	57—d	58—c	59—b	60—b
61—d	62—c	63—c	64—d	65—c	66—b	67—a	68—a	69—c	70—b	71—c	72—d
73—d	74—b	75—b	76—d	77—c	78—d	79—b	80—a	81—c	82—a	83—b	84—d
85—b	86—d	87—d	88—a	89—b	90—b	91—d	92—a	93—a	94—a	95—c	96—a
97—d	98—b	99—d	100—b	101—d	102—a	103—d	104—a	105—c	106—a	107—a	108—c
109—b	110—b	111—b	112—d	113—b	114—a	115—a	116—b	117—b	118—c	119—c	120—c
121—d	122—c	123—b	124—c	125—c	126—c	127—a	128—c	129—b	130—b	131—b	132—c
133—d	134—d	135—a	136—c	137—d	138—c	139—a	140—b	141—a	142—a	143—c	144—d
145—b	146—b	147—d	148—d	149—b	150—a	151—c	152—a	153—a	154—b	155—b	156—a
157—b	158—b	159—d	160—c	161—c	162—b	163—b	164—d	165—a	166—b	167—d	168—d
169—d	170—d	171—a	172—b	173—c	174—b	175—c	176—d	177—d	178—b	179—c	180—a
181—a	182—c	183—d	184—c	185—b	186—a	187—a	188—b	189—d	190—c	191—c	192—a
193—d	194—c	195—d	196—c	197—b	198—b	199—c	200—d	201—a	202—d	203—c	204—b
205—b	206—b	207—b	208—c	209—c	210—b	211—a	212—d	213—b	214—b	215—d	216—b
217—c	218—a	219—a	220—c	221—d	222—d	223—c	224—d	225—a	226—b	227—d	228—d
229—a	230—d	231—d	232—d	233—c	234—d	235—d	236—a	237—a	238—b	239—b	240—b
241—c	242—a	243—d	244—c	245—a	246—c	247—c	248—a	249—b	250—c	251—d	252—b
253—d	254—d	255—d	256—b	257—b	258—b	259—b	260—b	261—d	262—a	263—c	264—b
265—b	266—b	267—a	268—d	269—c	270—c	271—c	272—b	273—c	274—b	275—a	276—d
277—b	278—a	279—b	280—a	281—c	282—b	283—b	284—d	285—a	286—b	287—a	288—c
289—a	290—d	291—a	292—a	293—b	294—c	295—b	296—b	297—c	298—d	299—a	300—b
301—c	302—b	303—b	304—d	305—a	306—c	307—d	308—c	309—c	310—c	311—a	312—b
313—d	314—d	315—a	316—a	317—c	318—c	319—a	320—b	321—c	322—b	323—d	324—a
325—c	326—d	327—b	328—b	329—a	330—a	331—d	332—a	333—b	334—d	335—d	336—c

EXPLANATION OF SELECTED QUESTIONS (*)

17. PS-II is reduced by pulling electrons from water which leads to photolysis of water.
23. In cyclic photophosphorylation, only PS-I is involved.
32. Glucose phosphates formed in photosynthesis are asymmetrically lebelled, is called Gibb's effect.
42. In CAM plants, malic acid is formed during night without Kranz anatomy.
46. In Calvin cycle, three molecules of CO_2 will require $3 \times 3 = 9$ ATP and $2 \times 3 = 6$ $NADPH_2$.
50. The key compound of C-3 cycle or Calvin cycle is 3-PGAL as it is starting point for many other metabolic pathways in the plant.
57. Increase in CO_2 concentration upto 20 times than normal (300 ppm) leads to increase in rate of photosynthesis.
69. Photosynthesis throughout the day will lead to greater dry weight of green leaves in late afternoon.
86. Chlorophyll–a and carotenes are common pigments of all classes of algae.
92. Members of chlorophyceae class (green algae) of algae will have same pigments as those of grasses and trees, *i.e.*, chlorophyll–a, chlorophyll–b and carotenoids.
151. After 680 nm of wavelength of light, PS-II activity is disrupted and it is reason behind red drop.
159. Mn and Cl help in photolysis of water.
166. Bacteriochlorophyll is having 2H-atoms more than chlorophyll-a.
170. Cyanobacteria or blue-green algae have both pigment systems.
188. Photorespiration is a wasteful phenomenon.
195. The concentration of CO_2 remains constant in atmosphere as it is released in respiration.
197. 300 ppm (0.03%) is normal concentration of CO_2 in the atmosphere and hence there is no effect on plants.
211. Sugar cane is most efficient converter of solar energy.
221. Phycobilins (including phycocyanin) are pigments of PS-II.
224. $NADPH_2$ formed during light reaction of photosynthesis is reducing power in dark reaction of photosynthesis.
236. RuBP-carboxylase in high O_2/CO_2 conditions, behaves like RuBP-oxygenase.
252. Agranal chloroplasts are present in bundle sheaths of C-4 plants.
269. Mn is required for photolysis of water.
280. C-4 plants can photosynthesize in poor concentration of CO_2 as they get internal supply of CO_2.
282. 90% photosynthesis in world is carried out by algae (phytoplanktons).
285. Cyclic photophosphorylation is the most effective anaerobic phosphorylation mechanism.
287. CO_2 is usually limiting factor in photosynthesis under field conditions.
308. PEP-carboxylase (PEPCO) is important enzyme in C-4 cycle or C-4 plants.
317. Photosynthesis will be efficient if 35% of usable radiant energy entering the reaction site is converted into potential energy.
321. RuBP-oxygenase is a form of Rubisco, which occurs in chloroplast.
336. Carotenoids mainly absorb violet, indigo and blue wavelength of spectrum in higher plants.

- Due to accumulation of lactic acid in muscles, these get fatigued.

(c) Acetic acid fermentation : It occurs in acetic acid bacteria.

$$\underset{\text{Pyruvic acid}}{CH_3COCOOH} \xrightarrow[-CO_2]{} \underset{\text{Acetaldehyde}}{CH_3CHO} \xrightarrow{H_2O} \underset{\text{Acetic acid}}{CH_3COOH}$$

(d) **Butyric acid fermentation :** It occurs in *Clostridium butyricum* bacteria.

Pyruvic acid → Acetoacetic acid → Butyric acid

- Number of ATP mol. evolved in one complete cycle of anaerobic respiration is 2 (two).

Aerobic respiration

If molecular O_2 is present, then aerobic oxidation of pyruvic acid formed in glycolysis, occurs.

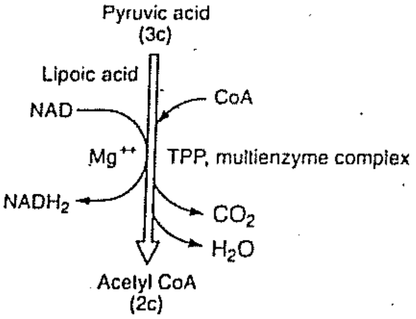


Fig. 24.3. Formation of acetyl CoA from pyruvic acid

- The pyruvic acid is **oxidatively decarboxylated** to form **acetyl CoA.** This formation of acetyl CoA from pyruvic acid needs a **multienzyme complex** and 5 **essential cofactors,** *i.e.,* Lipoic acid, CoA, Mg^{2+}, NAD, TPP (Thiamine pyrophosphate).
- This acetyl CoA acts as a 'connecting link' between glycolysis and Krebs' cycle.
- This formation of acetyl CoA is the intermediate step and results in production of 2 mols. of CO_2 and 2 mols. of $NADH_2$.

Krebs' cycle or Tricarboxylic acid cycle (TCA) or Citric acid cycle

Acetyl CoA formed from pyruvic acid in intermediate step, enters into Krebs' cycle or TCA or Citric acid cycle. Different reactions of this cycle were studied in detail by English biochemist **Hans Krebs**, thus is called **Krebs' cycle.** This is also called **TCA-cycle** because many tricarboxylic acids (having 3-COOH group) are produced in this cycle (citric acid, cis-aconitic acid, iso-citric acid). (Fig. 24.4)

It is also called **Citric acid** cycle (As citric acid is first product).

- This cycle was given by H. Krebs in 1937 and he got Nobel Prize for this work in 1953.
- Krebs' cycle occurs in **matrix of mitochondria** as its enzymes are present in matrix except **Succinic dehydrogenase,** which is found attached to inner mitochondrial membrane.
- This Krebs' cycle or citric acid cycle acts as a **common metabolic (oxidative) pathway for carbohydrates proteins and fats** (fats on hydrolysis form fatty acids which on β-oxidation give rise to acetyl CoA. Similarly, proteins give rise to amino acids like aspartic acid and glutamic acid. Aspartic acid gives rise to OAA or oxaloacetic acid or may be formed from OAA. Glutamic acid gives rise to α-ketoglutaric acid or may be formed from it).
- In Krebs' cycle, there are **4 oxidation steps** (where dehydrogenation reaction occurs, *i.e.,* catalysed by dehydrogenases).
- Besides being catabolic, Krebs' cycle also provides a number of intermediates which are used in different anabolic pathways to form important biomolecules like glutamic acid, aspartic acid, etc., hence this cycle is **Amphibolic in nature.**

Energy gain in one complete cycle of aerobic respiration : Energy gain in complete oxidation of one mole of glucose is:

$$\text{Glycolysis} \rightarrow 2ATP + 2NADH_2 = 8ATP \quad 1$$
$$2NADH_2 \xrightarrow{ETS} 6\ ATP$$

$$\text{Intermediate step} = 2NADH_2 \xrightarrow[ETS]{} = 6ATP \quad 2$$

$$\text{Krebs' cycle} = 6NADH_2 + 2FADH_2 + 2ATP = 24\ ATP$$
$$6NADH_2 \xrightarrow{ETS} 18\ ATP \qquad 2FADH_2 \xrightarrow{ETS} 4\ ATP \quad 1+2+3$$

$$\text{Total} = 38\ ATP$$

24
8
32

1 ATP = 7.3 kcal (7300 calories)

∴ 38 ATP = 38 × 7.3 = 277.4 kcal

Therefore, efficiency of aerobic respiration is

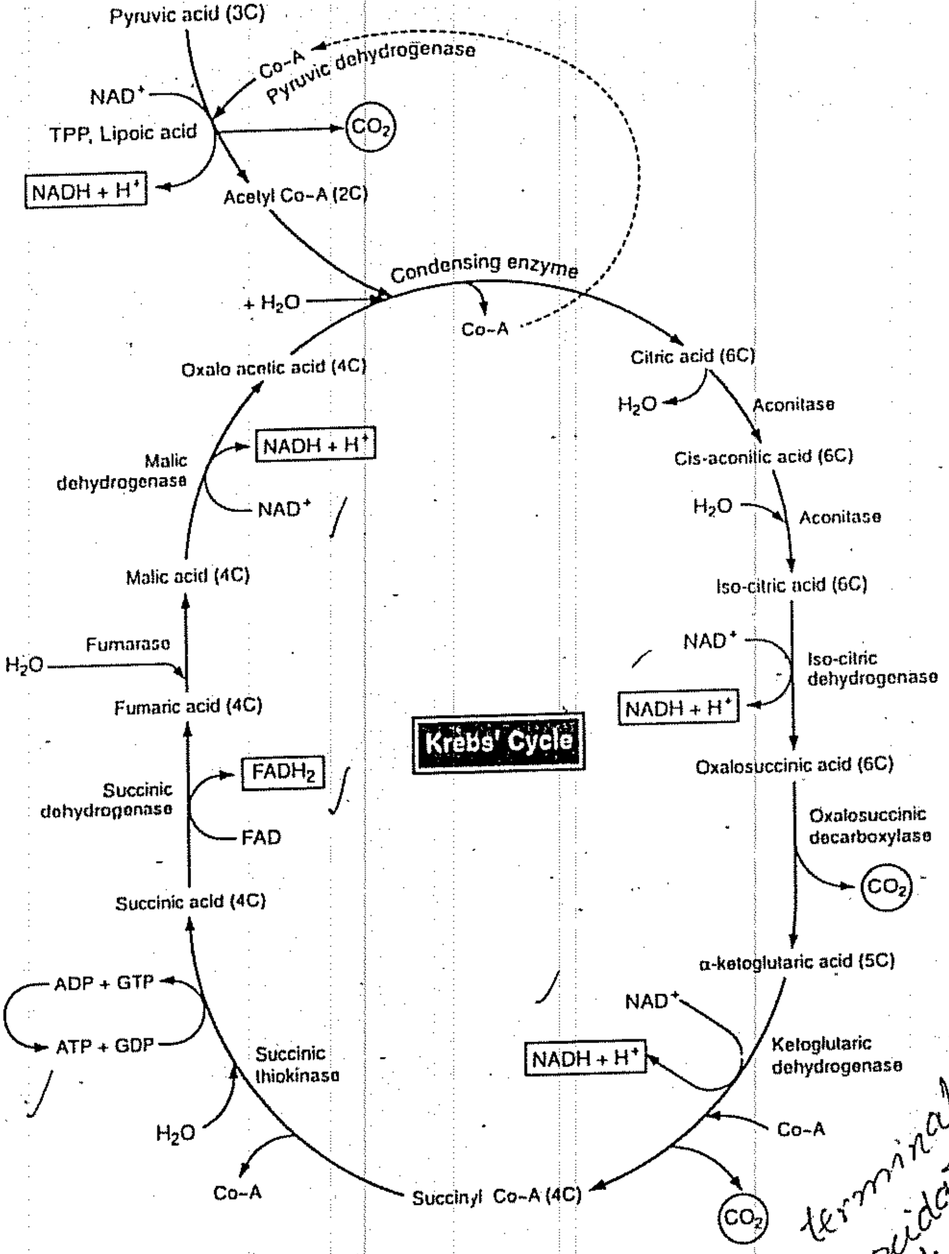
$$= \frac{277 \cdot 4}{673} \times 100$$
$$= 40\%$$

Rest is lost as heat.

- **ATP** (adenosine triphosphate) is called **energy-currency** of cells. ATP is energy rich compound where energy is present in terminal **pyrophosphate bonds.**
- General equation of respiration is biochemically wrong and the correct equation should be:

$$C_6H_{12}O_6 + 6O_2 + 10H_2O \longrightarrow 6CO_2 + 16H_2O + E$$

(As $10H_2O$ molecules are used and $16H_2O$ molecules are evolved in complete cycle of aerobic respiration).


Pyruvic acid (3C)
Co-A
Pyruvic dehydrogenase
NAD⁺
TPP, Lipoic acid
CO₂
NADH + H⁺
Acetyl Co-A (2C)
Condensing enzyme
+ H₂O
Co-A
Citric acid (6C)
H₂O
Aconitase
Cis-aconitic acid (6C)
H₂O
Aconitase
Iso-citric acid (6C)
NAD⁺
Iso-citric dehydrogenase
NADH + H⁺
Oxalosuccinic acid (6C)
Oxalosuccinic decarboxylase
CO₂
α-ketoglutaric acid (5C)
NAD⁺
Ketoglutaric dehydrogenase
NADH + H⁺
Co-A
CO₂
Succinyl Co-A (4C)
Co-A
H₂O
Succinic thiokinase
ADP + GTP
ATP + GDP
Succinic acid (4C)
Succinic dehydrogenase
FAD
FADH₂
Fumaric acid (4C)
Fumarase
H₂O
Malic acid (4C)
Malic dehydrogenase
NAD⁺
NADH + H⁺
Oxalo acetic acid (4C)
Krebs' Cycle

terminal
oxidation
dehydrogenase

Fig. 24.4. Krebs cycle or TCA-cycle

Terminal oxidation or Oxidative phosphorylation or Electron transport system (ETS) or Oxidative production of ATP :

Last step of aerobic respiration is oxidation of reduced co-enzymes, *i.e.*, $NADH_2$ and $FADH_2$ by molecular oxygen through FAD, CoQ (ubiquinone), Cyt. b, Cyt. c_1, Cyt. c, Cyt. a and Cyt a_3.

- Two hydrogen atoms or electrons move from $NADH_2$ and travel through this ETS chain and finally combine with half molecule of O_2 to form water and hence it is known as **terminal oxidation.** The electron carriers forming electron transport chain are **associated with inner mitochondrial membrane.** Further these electron carriers form **four structural complexes** (Ubiquinone and Cyt. c are not part of any complex).

24
Plant Physiology (IV)

RESPIRATION, TRANSLOCATION OF ORGANIC FOOD

- **Respiration :** General, aerobic and anaerobic respiration, protoplasmic and floating respiration, mechanism of respiration—Glycolysis, Krebs' cycle, terminal oxidation, pentose phosphate pathway, 38 or 36 ATP molecules produced in oxidation of one glucose molecule, R. Q., factors affecting respiration, light compensation point, Pasteur's effect, photorespiration, differences between photorespiration and normal respiration, glyoxylate cycle
- **Translocation of organic food or solutes :** General, directions of translocation, path of translocation of solutes, mechanism of translocation of solutes, factors affecting translocation of solutes.

RESPIRATION

Respiration is a **vital process** and is primarily an energy yielding process. Here high energy rich compounds generally carbohydrates or proteins or lipids are broken down into simple substances and large amount of energy is released.

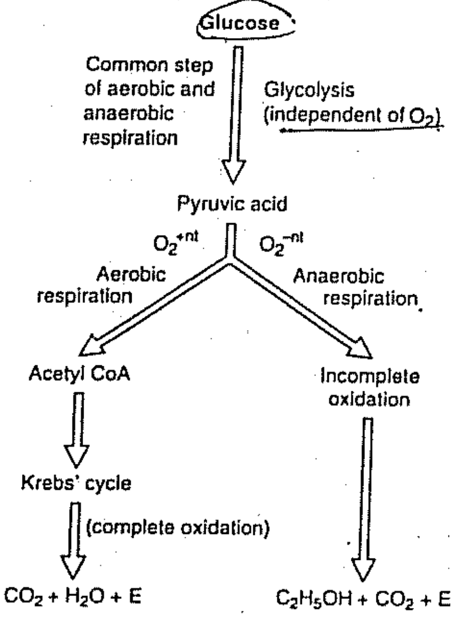


Fig. 24.1. Relation between aerobic and anaerobic respiration

So respiration is a catabolic, energy releasing, oxidative process.

Or

It is **catabolic, exothermic** and **oxidative** process.

- Respiration is represented by following general equation:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 673 \text{ kcal}$$

(now considered to be 686 kcal)

But the mechanism is not so simple as is represented by equation, it is rather, a complex process and completed in 2 main steps.

Aerobic and anaerobic respiration

The respiration which occurs in presence of O_2 and is responsible for activity of all organisms, is called **aerobic respiration.** Further the respiration which occurs in absence of O_2 is **anaerobic respiration.**

Anaerobic respiration occurs in some fungi and bacteria.

Facultative anaerobes : Which require O_2 but can respire in absence of O_2 also, *e.g.*, butyric acid bacteria, lactic acid bacteria, *Bacillus phosphorescence.*

Obligate anaerobes : Respire in total absence of O_2 or negligible O_2, *e.g.*, *Clostridium.*

Protoplasmic and floating respiration

Blackmann gave the term **'Protoplasmic respiration'** to the respiration of starved leaves, where proteins act as respiratory substrate.

Floating respiration is normal respiration where carbohydrates are used as respiratory substrate.

Mechanism of respiration

Glucose (Hexose sugar) is the chief respiratory substrate. Initial step of aerobic and anaerobic respiration is the same, *i.e.*, glucose is converted into 2 mols. of pyruvic acid (**Glycolysis**). Further fate of pyruvic acid is dependent upon presence or absence of O_2.

Glycolysis

The term glycolysis is given to a sequential series of reactions which occur in different tissues, starts with 1 mol. of **hexose sugar** (glucose) and ends with 2 mols. of **pyruvic acid.**

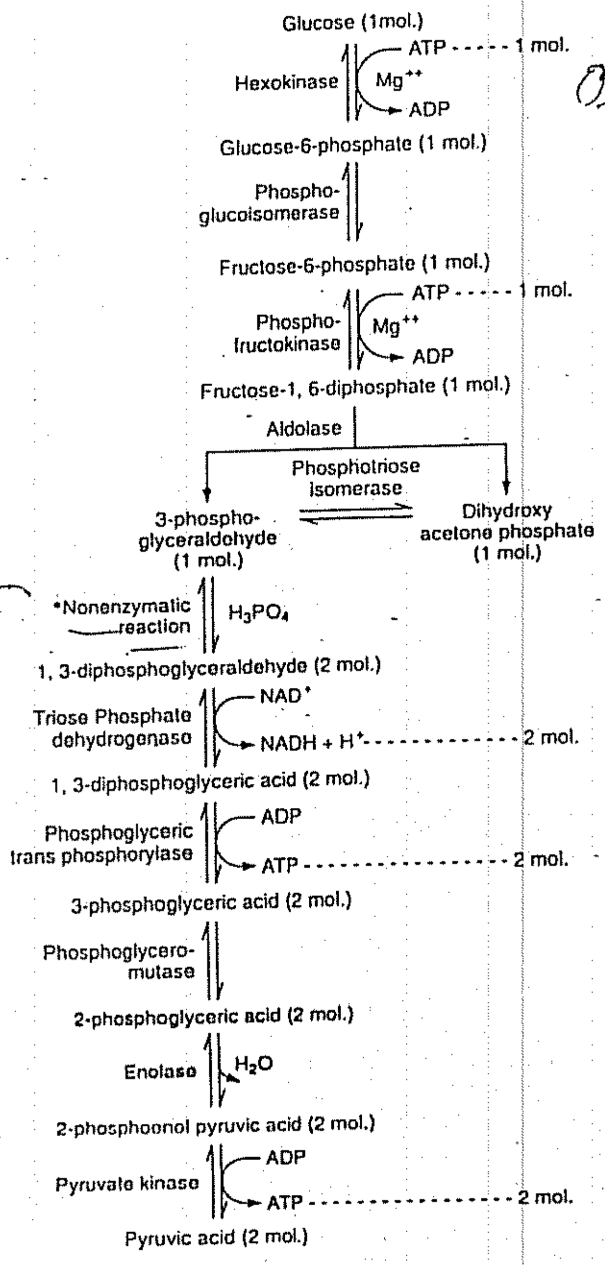

Glucose (1mol.)
ATP ----- 1 mol.
Hexokinase
Mg⁺⁺
ADP
Glucose-6-phosphate (1 mol.)
Phospho-glucoisomerase
Fructose-6-phosphate (1 mol.)
ATP ----- 1 mol.
Phospho-fructokinase
Mg⁺⁺
ADP
Fructose-1, 6-diphosphate (1 mol.)
Aldolase
Phosphotriose isomerase
3-phospho-glyceraldehyde (1 mol.)
Dihydroxy acetone phosphate (1 mol.)
•Nonenzymatic reaction
H₃PO₄
1, 3-diphosphoglyceraldehyde (2 mol.)
NAD⁺
Triose Phosphate dehydrogenase
NADH + H⁺ ----------- 2 mol.
1, 3-diphosphoglyceric acid (2 mol.)
ADP
Phosphoglyceric trans phosphorylase
ATP ---------------- 2 mol.
3-phosphoglyceric acid (2 mol.)
Phosphoglycero-mutase
2-phosphoglyceric acid (2 mol.)
Enolase
H₂O
2-phosphoenol pyruvic acid (2 mol.)
ADP
Pyruvate kinase
ATP ---------------- 2 mol.
Pyruvic acid (2 mol.)

Fig. 24.2. Glycolysis or EMP-pathway

- Glycolysis is independent of O_2 (Hence common in both aerobic and anaerobic conditions).
- All the reactions of glycolysis are **reversible.**
- Glycolysis is completed in cytoplasm.
- Glycolysis is also known as **EMP** pathway, after the names of 3 German scientists, *i.e.*, **Embden, Meyerhof** and **Parnas,** who discovered different reactions of glycolysis.
- All the reactions of glycolysis are enzymatic except one.

Glucose

- Glycose is the most common substrate in glycolysis.

(Starch or any other carbohydrate is first converted into glucose).

∴ Net gain of

$$ATP = 4\ ATP - 2\ ATP = 2\ ATP$$

Further $2NADH_2$ molecules are also produced, which on oxidative phosphorylation, give rise to $2 \times 3 = 6$ ATP molecules.

∴ Total gain of ATP = $2 + 6 = \underline{8\ ATP.}$

- Number of CO_2 molecules evolved in one complete cycle of glycolysis is zero (nil).
- Further fate of pyruvic acid depends upon presence or absence of oxygen, *i.e.*, in aerobic and anaerobic respiration.

Anaerobic respiration or Fermentation

In absence of O_2, **fermentation** or **anaerobic respiration** occurs. This term **'fermentation'** was first used by **Pasteur** (1857). Further **Buchner** discovered 'Zymase-complex enzyme' from cells of yeast capable of fermentation.

○ Fermentation or anaerobic respiration is completed in cytoplasm.

Different types of fermentation or anaerobic respiration are:

(a) **Alcoholic fermentation :** Most common type. It occurs in some fungi (yeast) and higher plants during anaerobic conditions. It is completed in 2 steps:

$$\text{(i)}\ \underset{\text{Pyruvic acid}}{2CH_3COCOOH} \xrightarrow{\text{Decarboxylase}} \underset{\text{Acetaldehyde}}{2CH_3CHO} + 2CO_2$$

$$\text{(ii)}\ \underset{\text{Acetaldehyde}}{2CH_3CHO} + 2NADH_2 \xrightarrow{\text{Alcohol dehydrogenase}} \underset{\text{Ethyl alcohol}}{2C_2H_5OH} + 2NAD$$

(b) **Lactic acid fermentation :** It occurs in lactic acid bacteria and muscles.

$$\underset{\text{Pyruvic acid}}{CH_3COCOOH} + NADH_2 \xrightarrow{\text{Lactic dehydrogenase}} \underset{\text{Lactic acid}}{CH_3CHOHCOOH} + NAD$$

During this electron transport FAD and Fe of different cytochromes are successively reduced and oxidised and at certain points, enough energy is released which is used to bind ADP with ip to form ATP. As this oxidation involves ATP production, so it is called **oxidative phosphorylation.**

- Oxidative phosphorylation occurs on F_1 particles or **oxysomes** present on cristae (inner membrane) of mitochondria.
- Oxidative phosphorylation is inhibited by **2, 4-dinitrophenol.**

During electron transfer, ATP is produced at following places:

(a) When H-atom or electrons are transferred from NADH$_2$ to FAD.

(b) When H-atom or electrons are transferred from Cyt. b to Cyt. c$_1$.

(c) When H-atoms or electrons are transferred from Cyt. a to Cyt. a$_3$. (Fig. 24.5)

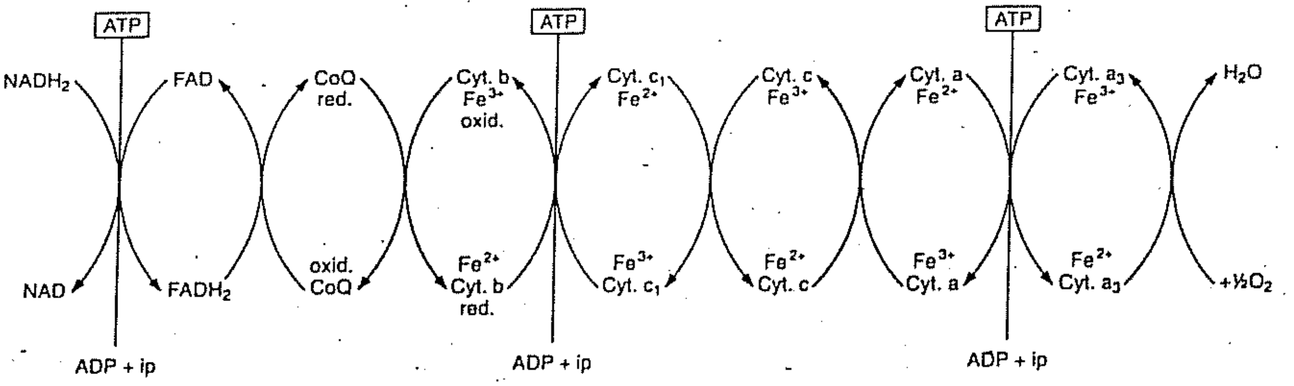


Fig. 24.5. Electron transport system and oxidative phosphorylation

So here we see that by oxidation of 1 mol. of NADH$_2$, **3 ATP** molecules are produced and by oxidation of 1 mol. of FADH$_2$, **2 ATP** molecules are produced.

- In electron transport chain, each electron acceptor or carrier has a more positive redox potential (higher electron affinity) than the previous one and with each successive transfer, the electrons loose additional free energy, which is utilized to generate a **proton gradient** across the inner mitochondrial membrane (*i.e.*, energy is utilized in transport of protons (H$^+$) from the matrix to outer side of inner mitochondrial membrane and higher proton concentration is created here). Now the protons return to the matrix down the proton gradient. This return occurs through oxysomes or $F_0 - F_1$ particles on inner mitochondrial membrane. The F_1 head-piece of oxysome functions as ATP-synthetase which synthesizes ATP from ADP and ip (inorganic phosphate) using energy from proton gradient or ATP synthetase becomes active in ATP formation only when there is a proton gradient having high concentration of protons on F_0 side (base) as compared to F_1 side (head piece) of $F_0 - F_1$ particles or oxysomes. This is called **Chemiosmotic hypothesis of ATP synthesis** or oxidative phosphorylation given by **Peter Mitchel** (1961) for which he was awarded **Nobel Prize** in 1978. This is the most accepted mechanism of oxidative phosphorylation.

Pentose phosphate pathway (PPP) or Hexose monophosphate shunt or Direct oxidation of glucose or Warburg's and Dickens' pathway:

Glycolysis is the main pathway of breaking down of glucose but there are certain inhibitors of glycolysis like arsenates, florides and iodoacetic acid which inhibit different steps of glycolysis. So in absence of glycolysis, glucose utilization should be stopped completely but this glucose utilization still continues even in absence of glycolysis. This has led to an alternate pathway of glucose utilization or respiration which is known as Pentose phosphate pathway or Hexose monophosphate shunt, in which direct oxidation of glucose-6-phosphate occurs into 6-phosphogluconic acid which converts into Ribulose-5-phosphate.

- PPP was given by **Warburg** and **Dickens** and is completed in **cytoplasm in presence of oxygen.**
- Here 6 molecules of CO$_2$ and 12 molecules of NADPH$_2$ are produced by oxidation of one glucose molecule. Further 36 ATP molecules are produced by oxidative phosphorylation of 12 NADPH$_2$.

38 ATP or 36 ATP molecules are produced in oxidation of 1 mol. of glucose in aerobic respiration:

2 mols. of NADH$_2$ produced in glycolysis in cytoplasm have to go inside mitochondria for oxidative phosphorylation but mitochondrial membrane is not permeable to NADH$_2$ and hence the electrons or H-atoms of NADH$_2$ go inside mitochondria with the help of **'electron shuttles'**. Two types of shuttles are common: (Fig. 23.6)

1. Malate aspartate shuttle: When this electron shuttle occurs, transfer of electrons from NADH$_2$ in cytoplasm

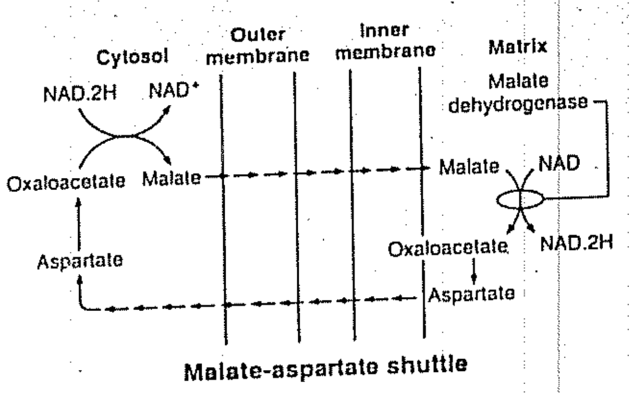

Cytosol
Outer membrane
Inner membrane
Matrix
NAD.2H
NAD⁺
Malate dehydrogenase
Oxaloacetate
Malate
Malate
NAD
Aspartate
Oxaloacetate
NAD.2H
Aspartate
Malate-aspartate shuttle

Fig. 24.6. Malate-aspartate shuttle scheme

occurs to NAD inside the mitochondria. This is more efficient and results in production of 38 ATP molecules.

2. **Glycerol-phosphate shuttle :** In this shuttle transfer of electrons from $NADH_2$ in cytoplasm occurs to FAD inside mitochondria and it results in production of 36 ATP molecules.

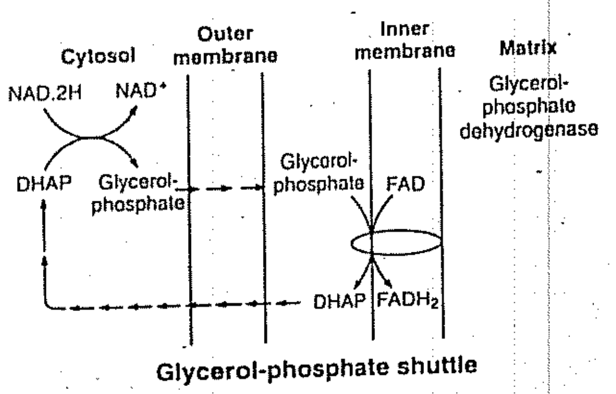

Cytosol
Outer membrane
Inner membrane
Matrix
NAD.2H
NAD⁺
Glycerol-phosphate dehydrogenase
DHAP
Glycerol-phosphate
Glycerol-phosphate
FAD
DHAP
FADH₂
Glycerol-phosphate shuttle

Fig. 24.7. Glycerol-phosphate shuttle scheme

- Type of shuttle depends upon type of tissue involved and prevailing conditions.

Respiratory Quotient (R.Q.)

R.Q. is defined as ratio of volume of CO_2 released to O_2 absorbed in respiration.

$$\therefore \quad R.Q. = \frac{\text{Vol. of } CO_2}{\text{Vol. of } O_2}$$

- Value of R.Q. varies from one respiratory substrate to another.

e.g.,

(i) When carbohydrates (glucose) are the respiratory substrate : Then value of R.Q. = 1 **(unity).**

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + E$$

$$\therefore \quad R.Q. = \frac{6}{6} = 1$$

(ii) When lipids or fats are respiratory substrate : Then value of R.Q. < 1 (0·7) or **less than unity because lipids are** poor in O_2 and hence require more O_2 for their oxidation.

$$\underset{\text{Tripalmitin(fat)}}{C_{51}H_{98}O_6} + 145O_2 \longrightarrow 102CO_2 + 98H_2O + E$$

$$\therefore \quad R.Q. = \frac{102}{145} = 0{\cdot}7\ (< 1)$$

(iii) When proteins are respiratory substrate : Then value of R.Q. is < 1 (0·8 – 0·9).

(iv) When organic acids are respiratory substrate : Then value of R.Q. is more than 1 **(more than unity).**

$$\underset{\text{Malic acid}}{2C_4H_6O_5} + 3O_2 \longrightarrow 4CO_2 + 3H_2O + E$$

$$\therefore \quad R.Q. = \frac{4}{3} = 1{\cdot}33\ (> 1)$$

(v) When incomplete oxidation of carbohydrates occurs : *e.g.*, in CAM plants (*e.g.*, *Opuntia*), value of R.Q. is zero (0).

$$2C_6H_{12}O_6 + 3O_2 \longrightarrow \underset{\text{Malic acid}}{3C_4H_6O_5} + 3H_2O$$

$$R.Q. = \frac{0}{3} = 0$$

(vi) In anaerobic respiration : Very high value of R.Q. occurs.

$$C_6H_{12}O_6 \longrightarrow C_2H_5OH + 2CO_2$$

$$\therefore \quad R.Q. = \frac{2}{0} = \infty \text{ (infinity)}$$

i.e., high value of R.Q. is obtained.

○ R.Q. is measured with the help of apparatus **Ganong's Respirometer.**

By knowing the value of R.Q., we can say which respiratory substrate is being used.

Factors affecting respiration

(A) External factors or Environmental factors

(i) **Temperature:** Optimum temperature for respiration is 30°C.

Minimum temperature is 0°C
Maximum temperature is 45°C

○ At low temperature, activity of enzymes is less and hence low respiration and it is for this reason that vegetables and fruits are stored at low temperature (cold storage).

○ Q_{10} value or temperature coefficient value (increase in rate of a particular process with every 10°C increase in temperature) for respiration is **2–2.5.**

○ At high temperature (45°C or above), **denaturation of** enzymes occurs hence respiratory rate is decreased.

(ii) **O_2:** If O_2 conc. is decreased to **1.9%** in the atmosphere, then aerobic respiration stops and anaerobic respiration starts (Extinction point for aerobic respiration). But if O_2 is increased above 1.9%, then it is extinction point for anaerobic respiration.

(iii) CO_2 : With increase in CO_2 above normal (0.03%), rate of respiration decreases.

(iv) **Water :** Proper hydration of respiratory cells is must and decrease in water content decreases respiratory rate (As water is necessary for activity of enzymes).

- Dry seeds (8–12% of water) have negligible respiratory rate.

(v) **Light :** It has no direct effect, but indirectly increases respiration by increasing conc. of respiratory substrate by photosynthesis.

(vi) **Injury :** It leads to increase in respiration, because healing of wound needs more meristematic activity of cells, which needs energy provided by respiration.

(vii) **Salts or minerals :** If tissue is transferred from water to salt solution, then rate of respiration increases (salt respiration).

- It is because for optimum functioning of respiratory enzymes, some minerals are needed and their deficiency may cause decrease in rate of respiration.

(B) Internal factors or Plant factors

(i) **Amount and state of activity of protoplasm :** In young meristematic cells, rate of respiration is more than old mature cells (because amount of protoplasm and its activity are more in young meristematic cells).

(ii) **Concentration of respiratory substrate :** Increase in respiratory substrate increases respiration, provided all other factors are favourable.

Light compensation point

The organic food or carbohydrates produced in photosynthesis is utilized in respiration to release energy. There is a certain time either in the morning or evening when light intensity is such that **rate of respiration is exactly equal to rate of photosynthesis** or what is produced in photosynthesis is being utilized in respiration. This is called **light compensation point.**

Pasteur's effect

Inhibition of carbohydrate breakdown by increasing O_2 conc. in respiration is called **Pasteur's effect.**

Photorespiration

By using different techniques it has been found that rate of respiration is **3 to 5 times more** in green photosynthetic cells in presence of light. Based upon post-illumination burst of CO_2 in green cells, Decker (1955) gave the phenomenon of **photorespiration,** *i.e.*, the respiration which occurs in green cells in presence of light, is called photorespiration.

- 3 organelles are associated with photorespiration, *i.e.*, **chloroplast, peroxisomes and mitochondria.**
- Respiratory substrate in photorespiration is a 2-carbon compound **[Glycollic acid (2c)],** hence called C-2 cycle.
- **Photorespiration is a wasteful phenomenon** and there is no production of ATP and $NADH_2$.
- **RuBP-carboxylase** in normal O_2/CO_2 conc. acts as 'carboxylase' (Key enzyme of photosynthesis in C-3 plants).

$$\begin{array}{c}\text{RuBP}\\ \text{or}\\ \text{RuDP}\end{array} + CO_2 \xrightarrow[\text{RuBP–carboxylase}]{\overset{\text{Normal}}{O_2/CO_2}} \begin{array}{c}\text{2 mols. of Phosphoglyceric acid}\\ \text{(3–PGA)}\end{array}$$

But in high O_2/CO_2 ratio, RuBP-carboxylase acts as oxygenase (RuBP-oxygenase).

$$\text{RuBP} + CO_2 \xrightarrow[\text{RuBP–oxygenase}]{\text{High } O_2/CO_2} \text{3-PGA} + \text{Phosphoglycollic acid}$$

$$\big\downarrow -PO_4$$

Glycollic acid,
used as respiratory substrate in photorespiration.

- **RuBP-carboxylase and oxygenase** are same enzyme and is called **Rubisco,** *i.e.*, **Rubisco** is RuBP carboxylase-oxygenase enzyme system.
- **Rubisco is a large protein molecule and constitutes 16% of chloroplast protein. Further it is most abundant protein on earth.**

Differences between photorespiration and normal (dark) respiration

S. No.	Photorespiration	Normal respiration
(i)	It occurs in green photosynthetic cells only.	In all living cells (vital process).
(ii)	It is light dependent.	Light independent.
(iii)	It increases with increase in O_2 conc. (2–21%).	Saturated at low O_2 concentration.
(iv)	3 organelles-chloroplast, peroxisomes, mitochondria are involved.	Only mitochondria involved.
(v)	Respiratory substrate is glycollic acid (2c).	Respiratory substrate is generally hexose sugar or glucose. Sometimes proteins and lipids also.
(vi)	No ATP or $NADH_2$ produced.	ATP and $NADH_2$ produced.
(vii)	It is a wasteful phenomenon.	Useful phenomenon.
(viii)	It occurs in only C-3 plants.	It occurs both in C-3 and C-4 plants.

Glyoxylate cycle or Glyoxylic acid cycle

Kornberg and Krebs (1957) gave this cycle in *Pseudomonas* bacteria, *i.e.*, conversion of insoluble fats into soluble sugars is called glyoxylate cycle. This occurs in germinating fatty seeds.

- It is closely associated with Krebs' cycle and occurs in glyoxisomes.

Gluconeogenesis

TRANSLOCATION OF ORGANIC FOOD OR SOLUTES

Formation of organic food or carbohydrates occurs by green parts of the plant (leaves) as a result of photosynthesis. Non-green parts depend upon green parts for organic food and thus food is transported from green parts to non green parts of the plant. **"This movement of organic food or solute in soluble form from one organ to another organ is called translocation of solutes."** *e.g.*,

(i) From leaves to stem and roots for consumption.

(ii) In germinating seeds, insoluble food is converted into soluble form, which goes to growing parts of the seedling until it has developed leaves.

- Translocation of solutes takes place always from higher conc. (source or supply end) of its soluble form to lower conc. of its soluble form (sink or consumption end).
- Translocation of solutes mostly occurs in form of sucrose.

Directions of translocation of solutes

(i) Downward translocation : It is of most important type, *i.e.*, from leaves to stem and roots.

(ii) Upward translocation : From leaves to developing flowers, buds, fruits and also during germination of seeds and tubers, etc.

(iii) Radial translocation : From pith to cortex and epidermis.

Path of translocation of solutes

For downward translocation : Phloem is the path for downward translocation of organic food. Following evidences are in support of it:

(i) Tissues other than phloem cannot account for downward translocation of solutes : Because xylem is responsible for upward movement of water and minerals, so it cannot account for downward translocation of solute at the same time. Cortex and pith are not structurally suitable for this purpose. Thus only phloem is left (where there is end to end arrangement of sieve tubes united by sieve pores), which is responsible for translocation of solutes in downward direction.

(ii) Blocking of phloem : Blocking of sieve pores by **'callose'** during winter blocks translocation of solutes.

(iii) Analysis of phloem sap : Sucrose is found and further amount of sucrose is more in phloem during day time and lesser during night. But in xylem, sucrose is absent or negligible and no variation during day and night.

(iv) When a potted plant is allowed to photosynthesize in $^{14}CO_2$, sugars with C^{14} (radioactive C) is found in phloem.

(v) Ringing or girdling experiment : It was first performed by **Hartig** (1837). On removing the ring of bark (phloem + cambium) above the root at the base of stem, accumulation of food occurs in the form of swelling just above the ring, which suggests that in absence of phloem, downward translocation of food is stopped.

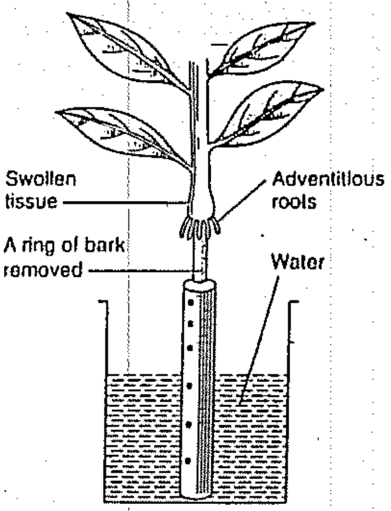


Fig. 24.8. Ringing experiment

- In a girdled plant, **roots die first** and ultimately shoot dies.

Path of upward translocation : It is also **phloem.**

Path of radial translocation : It is **medullary rays.**

Mechanism of translocation of solutes

Different theories have been put forward but **Munch mass flow theory** or **pressure flow** or **turgor flow theory** is most accepted one. It was given by **Munch** (1930) and supported by **Crafts.**

According to this theory, 'Translocation of solutes takes place enmass (in bulk) through phloem along a gradient of turgor pressure from higher conc. of its soluble form (source) to lower conc. of its soluble form (sink).

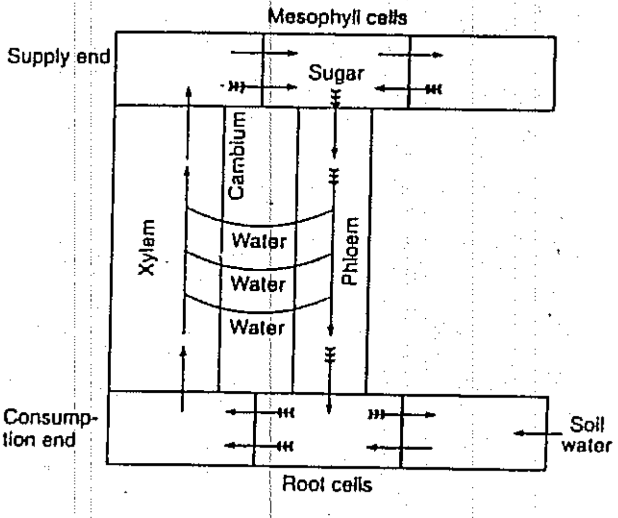


Fig. 24.9. Representation of translocation of organic solutes according to Munch

- Because in leaves (source), osmotic conc. remains always high (due to photosynthesis) and in roots (sink), osmotic conc. remains low, so mass flow of organic food continues from leaves to roots (*i.e.*, along a gradient of turgor pressure).

Objections

(i) This explains translocation of solutes only in one direction (downward at a time).

(ii) There is a controversy regarding magnitude of T.P. at supply end and in some cases, T.P. at root end (sink) is found to be more than source.

(iii) This is a simply physical process and does not require metabolic energy.

- **Phloem loading** and **unloading** are active processes (*i.e.*, require energy).

Some other theories of translocation of solutes are as follows:

(i) Diffusion hypothesis : Translocation of solutes takes place from higher conc. to lower conc. by simple diffusion but it is very slow process so **Mason and Maskell** gave 'Activated diffusion hypothesis', *i.e.*, diffusion using metabolic energy but is not confirmed.

(ii) Protoplasmic streaming theory : This theory was put forward by **de Vries** (1885).

According to this theory, translocation of solutes occurs in both the directions simultaneously by **cyclosis movements** of protoplasm, but rate possible by this process is only 1–5 cm/hour, whereas actual rate is about 100 cm/hour.

(iii) Transcellular streaming theory : By **Thaine** (1964). According to this theory, bidirectional translocation of solutes occurs through **proteinaceous transcellular strands** present in sieve tubes, but no such transcellular strands are found under electron microscope.

(iv) Electroosmotic theory : By **Fensom, Spanner and Jones.**

According to this theory, a current of potassium ions passes through sieve pores due to electroosmosis and sugar molecules attached to K^+ ions move through sieve tubes, but this needs experimental verification.

Factors affecting translocation of solutes

(i) Temperature : 25°C to 35°C is optimum temperature.

(ii) Oxygen : It is aerobic process so presence of O_2 is must.

(iii) Moisture stress : It reduces rate of translocation.

(iv) Light : Reduction in light intensity also reduces rate of translocation.

(v) Metabolic controls : As this process requires energy so all the factors which affect respiration also affect translocation of solutes.

MULTIPLE CHOICE QUESTIONS

*1. Respiration is a:
[✓ (a) Chemical change] (b) Mechanical process
[✓ (c) Vital process] (d) Physical process

2. When protein is used as a respiratory substrate, the respiration is called:
(a) Dark respiration (b) Protoplasmic respiration
(c) Floating respiration (d) Photorespiration

*3. Enzymes of glycolysis are present in: **(Raj. PMT 2001)**
(a) Mitochondrial matrix (b) Cristae
[✓ (c) Cytosol] (d) All of these

4. TCA cycle is:
(a) Catabolic (b) Anabolic
[✓ (c) Amphibolic] (d) None of these

5. Citric acid cycle occurs in: **(CPMT 1999; AFMC 2002)**
(a) Cytoplasm [✓ (b) Mitochondrial matrix]
(c) Cristae (d) None of these

6. Krebs' cycle is related with:
(a) Chlorophyll synthesis (b) Protein synthesis
(c) Fat synthesis [✓ (d) All of these]

*7. How many oxidation steps are there in aerobic respiration?
[✓ (a) 5] (b) 4
(c) 2 (d) 1

8. How many molecules of CO_2 are produced in one complete cycle of aerobic respiration?
(a) 3 (b) 4
[✓ (c) 6] (d) 8

9. Respiration is a process:
(a) Endergonic [✓ (b) Exergonic]
(c) Both (a) and (b) (d) None of these

10. Number of CO_2 molecules evolved in glycolysis is:
(a) 2 (b) 1
(c) 3 [✓ (d) 0]

11. Fermentation was discovered by:
(a) Aristotle (b) Theophrastus
[✓ (c) Pasteur] (d) Warburg

12. Zymase was discovered by:
(a) Lipmann (b) Pasteur
(c) Buchner (d) Altman

13. Anaerobic respiration results in ATP:
(a) 12 (b) 8
(c) 22 [✓ (d) 2]

14. Which is the connecting link between glycolysis and Krebs' cycle? **(CPMT 2003)**
(a) Iso-citric acid [✓ (b) Acetyl CoA]
(c) α-keto glutaric acid (d) Glucose

15. Energy currency of life processes is:
(a) AMP [✓ (b) ATP]
(c) RNA (d) DNA

*16. Respiration in bacteria takes place at:
(a) Cell wall [✓ (b) Plasma membrane]
(c) Nucleus (d) Cytoplasm

17. Amount of energy given by one molecule of ATP is: **(CPMT 2000)**
(a) 721 kcal (b) 7600 kcal
(c) 1000 kcal [✓ (d) 7·3 kcal]

18. The net gain of energy from one gram mole of glucose during aerobic respiration is:
(a) 2 ATP (b) 4 ATP
[✓ (c) 38 ATP] (d) 40 ATP

19. Which is associated with the enzyme aconitase in Krebs' cycle?
(a) Mn [✓ (b) Fe]
(c) Zn (d) Cu

20. The inhibitor of oxidative phosphorylation is:
(a) Azide (b) Cyanide
[✓ (c) 2,4-Dinitrophenol] (d) None of these

21. The universal hydrogen acceptor is:
[✓ (a) NAD] (b) FAD
(c) ATP (d) CoA

22. R.Q. is: **(BHU 1999; DPMT 2003)**
(a) $\frac{O_2}{CO_2}$ [✓ (b) $\frac{CO_2}{O_2}$]
(c) $CO_2 + O_2$ (d) $CO_2 - O_2$

23. Efficiency of aerobic respiration is:
(a) 60% (b) 45%
(c) 50% [✓ (d) 40%]

24. Who is associated with 'PPP'?
(a) Krebs [✓ (b) Warburg and Dickens]
(c) Pasteur (d) None of these

25. Hexose monophosphate shunt occurs in:
(a) Mitochondria [✓ (b) Cytoplasm]
(c) Both (a) and (b) (d) None of these

26. R.Q. of protein, carbohydrate, fats and organic acids are in order:
[✓ (a) $< 1, 1, < 1, > 1$] (b) $> 1, < 1, 1, 1$
(c) $1, 1, 0, -1$ (d) $0, < 1, 1, > 1$

27. Ganong's respirometer is used to measure:
(a) Rate of aerobic respiration
(b) Rate of anaerobic respiration
[✓ (c) R.Q.]
(d) None of the above

28. Q_{10} value of respiration is:
(a) 1 (b) 5
[✓ (c) 2] (d) 4

29. Injury leads to .... in respiration:
(a) Increase [✓ (b) Decrease]
(c) Remains constant (d) Increase or decrease

30. Inhibition by O_2 of the rate of carbohydrate breakdown is often called as:
(a) Gibb's effect (b) Warburg's effect
[✓ (c) Pasteur's effect] (d) None of these

31. In Krebs' cycle, how many water molecules are used?
(a) 2 [✓ (b) 8]
(c) 10 (d) 16

32. Who first used the term photorespiration?
(a) Pasteur (b) Krebs
(c) Warburg [✓ (d) Decker]

33. Photorespiration occurs in:
(a) All cells [✓ (b) Green cells]
(c) Living cells (d) None of these

34. The respiratory substrate in photorespiration is: (MPPMT 2002)
(a) Carbohydrates (b) Protein
[✓ (c) Glycollic acid] (d) Glyoxylic acid

35. Which is the most abundant protein on earth?
(a) Albumins (b) Plastocyanin
[✓ (c) Rubisco] (d) None of these

*36. How many ATP and NADH$_2$ are produced in photorespiration?
(a) 2 and 4 (b) 1 and 2
(c) 4 and 6 [✓ (d) Zero.]

37. The full form of Rubisco is:
(a) RuBP — carboxylase
(b) RuBP — oxygenase
[✓ (c) RuBP — carboxylase oxygenase]
(d) None of the above

38. Photorespiration occurs in: (MPPMT 2001; Kerala PMT 2002)
(a) Cytoplasm
(b) Mitochondria
(c) Chloroplast and peroxisomes
[✓ (d) Chloroplast, peroxisome and mitochondria]

39. Conversion of fat into sugar constitutes:
(a) EMP pathway (b) Rubisco cycle
[✓ (c) Glyoxylate cycle] (d) C–2 cycle

*40. C–2 cycle is associated with:
(a) Respiration
[✓ (b) Photorespiration]
(c) Dark reaction of photosynthesis
(d) Conversion of fat into sugar

41. Glyoxylic acid cycle was discovered by:
(a) Pasteur (b) Krebs and Lipmann
[✓ (c) Kornburg and Krebs] (d) Warburg and Dickens

42. Oxidative phosphorylation of one NADH$_2$ yields: (CET Karnataka 2000)
(a) 1 ATP (b) 2 ATP
[✓ (c) 3 ATP] (d) 4 ATP

43. Anaerobic respiration occurs in:
(a) Mitochondria only
[✓ (b) Cytoplasm only]
(c) Mitochondria and cytoplasm
(d) None of the above

*44. Cytochromes were first discovered by:
(a) Lipmann (b) Krebs
[✓ (c) Mc Munn] (d) Barnes

45. R.Q. of *Opuntia* is:
(a) 1 (b) Less than 1
(c) More than 1 [✓ (d) 0]

46. In the process of respiration, 180 g of glucose and 192 g of O$_2$ produce:
(a) 132 g of CO$_2$ + 54 g of H$_2$O
[✓ (b) 264 g CO$_2$ + 108 g H$_2$O]
(c) 528 g CO$_2$ + 216 g H$_2$O
(d) Only CO$_2$

47. Cytochromes are:
(a) O$_2$ acceptors (b) H$_2$ acceptors
[✓ (c) Electron acceptors] (d) None of these

48. Path of glucose breakdown to pyruvic acid was discovered by:
(a) Vishniac and Ochoa
(b) Krebs and Lipmann
[✓ (c) Embden, Meyerhof and Parnas]
(d) None of the above

2800 × 10
= 7.3

*49. A normal 72 kg adult man requires about 2800 kcal of energy per day, how many ATP molecules are required to produce such amount of energy?
(a) 380 (b) 280
(c) 384 (d) 584

50. Anaerobic respiration is low energy yielding because:
(a) Too much CO$_2$ accumulates in the cell
[✓ (b) Lactic acid is produced which prevents further oxidation]
[✓ (c) Glucose molecule is not fully oxidized]
(d) Glucose is unable to break in absence of O$_2$

*51. Instant source of energy is:
[✓ (a) Glucose] (b) Fats
(c) Proteins (d) Amino acids

52. Respiration is carried out by:
(a) Parenchymatous cells (b) All leaf cells
(c) All cells [✓ (d) All living cells]

53. A characteristic feature of ripening of some fruits like banana is a sudden increase in respiration which is known as:
[✓ (a) Climacteric] (b) Anthesis
(c) Climatic (d) Photorespiration

54. Translocation of solutes takes place from:
[✓ (a) Higher concentration of soluble form to lower concentration]
(b) Lower concentration to higher concentration
(c) Both (a) and (b)
(d) None of the above

55. Direction of translocation of solutes is:
(a) Upward (b) Downward
(c) Radial [✓ (d) All of these]

56. Which of the following represents 'sink'?
(a) Developing leaves (b) Meristem
(c) Roots [✓ (d) All of these]

57. Downward translocation of solutes takes place through: (DPMT 2003)
(a) Xylem [✓ (b) Phloem]
(c) Medullary rays (d) All of these

58. If a plant is girdled, which part dies first?
(a) Leaves (b) Stem
[✓ (c) Roots] (d) None of these

59. Which is most accepted theory of translocation of organic solution?
(a) Protoplasmic streaming theory
(b) Transcellular streaming theory
(c) Turgor flow theory
(d) None of the above

60. Protoplasmic streaming theory of translocation of solutes was put forward by:
(a) Munch (b) de Vries
(c) Thaine (d) None of these

61. 'Phloem loading' and 'phloem unloading' are:
(a) Active and passive processes respectively
(b) Both passive
(c) Both active
(d) Passive and active respectively

62. Which of the following is used in conversion of pyruvic acid to acetyl CoA?
(a) Oxidative phosphorylation
(b) Oxidative dehydrogenation
(c) Oxidative decarboxylation
(d) Oxidative dehydration

63. Formation of acetyl CoA from pyruvic acid needs:
(a) A single enzyme (b) Two enzymes
(c) Multienzyme complex (d) No enzyme

64. Which is non–enzymatic reaction?
(a) Phosphoglyceric acid → PEP
(b) 3-Phosphoglyceraldehyde → 1,3- diphosphoglyceraldehyde
(c) Pyruvic acid → acetyl CoA
(d) 1,3- Diphosphoglyceric acid → 3-PGA

65. Conversion of succinate to fumarate in Krebs' cycle is due to:
(a) Loss of electrons from it
(b) Removal of hydrogen from it
(c) Addition of O_2 to it
(d) None of the above

66. Which is correct sequence in Krebs' cycle?
(a) Iso-citric acid → oxalosuccinic acid → α-ketoglutaric acid
(b) Oxalosuccinic acid → iso-citric acid → α-ketoglutaric acid
(c) α-ketoglutaric acid → iso-citric acid → oxalosuccinic acid
(d) Iso-citric acid → α-ketoglutaric acid → oxalosuccinic acid

67. The reactions of glycolysis are:
(a) Reversible (b) Non reversible
(c) Both (a) and (b) (d) None of these

68. Which of the following trees would die quicker?
(a) Hollow hearted (b) Girdled
(c) Deciduous (d) Pruned

69. Translocation of carbohydrates in flowering plants occurs in form of:
(a) Glucose (b) Sucrose
(c) Starch (d) Maltose

70. Raw material for respiration is: **(Raj. PMT 1991)**
(a) Glucose and O_2 (b) Glucose and CO_2
(c) Glucose and carbon (d) Glucose and sucrose

71. ATP contains:
(a) Adenosine, ribose and phosphate
(b) Adenosine, deoxyribose and phosphate
(c) Adenine, ribose and phosphate
(d) Adenine, deoxyribose and phosphate

72. An indispensable role in energy metabolism is played by:
(a) Phosphorus (b) Lithium
(c) Sodium (d) Calcium

73. In annual plant, exchange of gases takes place mainly through:
(a) Stomata (b) Stem
(c) Leaf scars (d) Lenticels

74. Which of the following is the source of respiration?
(a) Stored food (b) RNA
(c) DNA (d) ATP

75. R.Q. for glucose is:
(a) 0.05 (b) 0.5
(c) 1 (d) 2

*76. Synthesis of ATP in mitochondria takes place: **(CPMT 1990)**
(a) In the matrix (b) At the outer membrane
(c) At the cristae (d) In the intracristae place

77. In plants energy is produced during the process of:
(a) Transpiration (b) Respiration
(c) Photosynthesis (d) Water absorption

78. A carbohydrate that does not require further digestion in plant cell is:
(a) Glucose (b) Starch
(c) Sucrose (d) Cellulose

79. Anaerobic respiration was first of all reported by:
(a) Maguenne (b) Kostychev
(c) Klein (d) Pfeffer

80. Respiration occurs
(a) Only in non-green cells in light
(b) Only in non-green cells both in light and dark
(c) In all living cells both in light and dark
(d) In all living cells only in light

81. Older stem of woody plants have structures which allow air to diffuse into the respiring cells. The structures are called:
(a) Leaf scars (b) Lenticels
(c) Stomata (d) Pores

82. Respiration is: **(CET Karnataka 1993)**
(a) An anabolic process (b) A catabolic process
(c) A chemical process (d) All of these

83. After respiration the conversion of energy is mainly in the form of:
(a) Glucose (b) ATP
(c) ADP (d) AMP

84. Anaerobic respiration is also known as:
(a) Intramolecular respiration
(b) Intermolecular respiration

(c) Extramolecular respiration
(d) Molecular respiration

85. Respiration differs from the process of combustion in the fact that:
(a) All the energy stored in glucose is released at once due to combustion
(b) All the energy stored in glucose is gradually released due to combustion
(c) Comparatively large quantity of energy is produced due to combustion
(d) The carbohydrate acts as the combustion substance

86. Energy obtained by a cell from catabolic reactions is stored immediately in the form of:
(a) Pyruvic acid (b) Glucose
(c) ATP (d) DNA

87. Energy rich compound that is produced during biological oxidation of glucose is:
(a) Adenosine monophosphate
(b) Adenosine triphosphate
(c) ADA
(d) AMP

88. Protein rich pulses have R.Q. equal to:
(a) One (b) More than one
(c) Less than one (d) None of these

89. In which of the following, respiration in absence of oxygen too takes place?
(a) Man (b) Yeast
(c) Potato (d) *Spirogyra*

90. How many ATP molecules are produced for every glucose molecule consumed in respiration? **(CBSE 1993, 2002; CPMT 1997)**
(a) 34 (b) 36
(c) 38 (d) 32

91. Which is the final electron acceptor in respiration?
(a) Cytochromes (b) Dehydrogenase
(c) Oxygen (d) Hydrogen

92. The intermediate compound common for aerobic and anaerobic respiration is: **(BHU 1999)**
(a) PGA (b) Acetic acid
(c) Pyruvic acid (d) Succinic acid

***93.** Maximum number of ATP is obtained from: **(Raj. PMT 1990)**
(a) Glucose (b) Palmitic acid
(c) Malic acid (d) β-amino acid

94. In *Opuntia* in night, the respiratory quotient (R.Q.) will be:
(a) Zero (b) One
(c) Less than one (d) More than one

95. In how many steps CO_2 is released in aerobic respiration?
(a) One (b) Six
(c) Three (d) Twelve

96. Pyruvic acid is produced at the end of: **(AFMC 1993)**
(a) Glycolysis (b) Krebs' cycle
(c) Calvin Cycle (d) Photorespiration

97. What causes R.Q. to vary? **(Raj. PMT 1992)**
(a) Respiratory substrate (b) Respiratory product
(c) Light and O_2 (d) Temperature

***98.** If the volume of CO_2 liberated during respiration is more than the volume of O_2 used, the respiratory substance will be:
(a) Fats (b) Organic acids
(c) Proteins (d) Carbohydrates

99. The enzyme which converts glucose to glucose-6-phosphate is:
(a) Glucose synthetase (b) Hexokinase
(c) Phosphorylase (d) Glucose-6-phosphatase

100. R.Q. is zero when the respiratory substrate is:
(a) Completely oxidized (b) Incompletely oxidized
(c) Not oxidized at all (d) Reduced

101. Which is also formed alongwith ATP in glycolysis?
(a) $NADPH_2$ (b) $NADH_2$
(c) $FADH_2$ (d) FAD

102. The end products of aerobic respiration in plants are: **(Re. Ex. CPMT 1991)**
(a) CO_2 and energy (b) CO_2 and water
(c) H_2O and energy (d) CO_2 and O_2

103. In succulent plants, respiratory quotient is always less than one because of:
(a) Complete oxidation (b) Complete reduction
(c) Incomplete reduction (d) Incomplete oxidation

***104.** The net gain of ATP molecules in glycolysis is: **(CPMT 1997)**
(a) 0 (b) 2
(c) 4 (d) 8
(e) 36

105. Endoparasites respire:
(a) Without O_2 (b) With O_2
(c) With H_2O (d) Without H_2O

106. The oxidation of glucose to pyruvates and their subsequent breakdown is brought about by:
(a) Electron transfer system
(b) Respiratory enzyme system
(c) Cyclic electron system
(d) Respiratory phosphorylation

107. Total ATP production during EMP pathway is:
(a) 24 ATP molecules (b) 8 ATP molecules
(c) 38 ATP molecules (d) 6 ATP molecules

108. In anaerobic respiration in plants:
(a) Oxygen is taken in
(b) Oxygen is given out
(c) Carbon dioxide is given out
(d) Carbon dioxide is taken in

109. Which of the molecules listed below is a product of fermentation of glucose by yeast?
(a) $(C_6H_{10}O_5)_n$ (b) C_2H_5OH
(c) $C_6H_{12}O_6$ (d) CH_3OH

110. ATP is:
(a) An enzyme which brings about oxidation
(b) A molecule which contains high energy phosphate bonds

(c) A hormone
(d) A protein

111. R.Q. is less than one in: **(Raj. PMT 1991)**
(a) Starch (b) Sugar cane
(c) Glucose (d) Groundnut

112. Alcohol is produced during the process of:
(a) Photosynthesis (b) Aerobic respiration
(c) Anaerobic respiration (d) None of these

113. In the process of respiration, the potential energy stored in the organic compounds is released in the form of:
(a) Kinetic energy (b) Physical energy
(c) Chemical energy (d) Radiant energy

*114. The R.Q. of $C_{39}H_{72}O_6$ is: **(CPMT 1992)**
(a) 2.71 (b) 1.34
(c) 0.718 (d) 3.250

115. R.Q. is highest when respiratory substance is:
(a) Fat (b) Malic acid
(c) Glucose (d) Protein

116. What is the importance of respiration in plants?
(a) It provides oxygen to plants
(b) It liberates energy (ATP)
(c) It liberates carbon dioxide
(d) All of the above

117. During respiration in yeast: **(CPMT 1991)**
(a) Water and CO_2 are end products
(b) CO_2, C_2H_5OH and energy are end products
(c) H_2S, $C_6H_{12}O_6$ and energy are end products
(d) CO_2 is the only end product

*118. The formation of acetyl coenzyme A from pyruvic acid is the result of its: **(CPMT 1990)**
(a) Reduction (b) Dehydration
(c) Dephosphorylation (d) Oxidative decarboxylation

119. Alternate name for Krebs' cycle is:
(a) Citric acid cycle (b) Glycolate cycle
(c) Glyoxylate cycle (d) EMP pathway

120. Mitochondria is the site of:
(a) CO_2 uptake in photosynthesis
(b) O_2 uptake during respiration
(c) The release of energy during respiration
(d) Cell divison

121. In complete oxidation of glucose into pyruvic acid with several intermediate steps is known as:
(a) T.C.A. pathway (b) Glycolysis
(c) H.M.S. pathway (d) Krebs' cycle

122. Fermentation is:
(a) Complete oxidation of carbohydrates
(b) Incomplete oxidation of carbohydrates
(c) Anaerobic respiration
(d) None of the above

123. Fermentation is conducted by:
(a) All fungi
(b) All bacteria
(c) Some fungi and some bacteria
(d) All micro-organisms

124. Oxidative phosphorylation is formation of: **(CBSE 1992)**
(a) $NADPH_2$ in respiration
(b) ATP in respiration
(c) $NADPH_2$ in photosynthesis
(d) ATP in photosynthesis

125. Which of the following is important in carbohydrate and fat metabolism?
(a) Carbon dioxide (b) Acetyl coenzyme A
(c) Pyruvic acid (d) Citric acid

126. Respiratory enzymes are located in:
(a) Mitochondrial matrix or (Mitochondria)
(b) Perimitochondrial space
(c) Cristae
(d) Outer membrane

127. Which of the following is the site of respiration within the cell?
(a) Ribosomes (b) Nucleus
(c) Golgi body (d) Mitochondria

128. The first compound of TCA cycle is:
(a) Oxalosuccinic acid (b) Oxaloacetic acid
(c) Citric acid (d) Cis-aconitic acid

129. Which of the following involves the loss of two protons and two electrons?
(a) Deamination (b) Dehydrogenation
(c) Carboxylation (d) None of these

130. ATP formation occurs when there is change in:
(a) Glucose → Glucose-6-phosphate
(b) Pyruvic acid → Acetyl CoA
(c) Fructose-6-phosphate → Fructose1-6 diphosphate
(d) Glucose-6-phosphate → Fructose-6-phosphate

131. How many ATP molecules should be produced from the complete oxidation of a mole of active acetate or acetyl CoA? **(CBSE 1990; Raj. PMT 1990)**
(a) 38 ATP (b) 15 ATP
(c) 12 ATP (d) 19 ATP

132. The Krebs' cycle begins with: **(CBSE 1991)**
(a) Pyruvic acid (b) Hydrochloric acid
(c) Corticosteroids (d) Lysine

133. In Krebs' cycle the hydrogen atoms removed at succinate level are accepted by:
(a) FAD (b) ADP
(c) ATP (d) NAD

*134. Pyruvate(pyruvic)dehydrogenase is used in converting:
(a) Pyruvate to glucose
(b) Glucose to pyruvate
(c) Pyruvic acid to lactic acid
(d) Pyruvate to acetyl CoA

135. Organelles which are regarded as "power house" of the cell and in which the oxidative reaction of the respiratory process takes place are?
(a) Chloroplasts (b) Ribosomes
(c) Endoplasmic reticulum (d) Mitochondria

136. ATP synthesis occurs on the:
(a) Matrix
(b) Outer membrane of mitochondrion

(c) Inner membrane of mitochondrion
(d) None of these

137. The net gain of energy from one molecule of sucrose in aerobic respiration is:
(a) 8 ATP (b) 38 ATP
(c) 40 ATP (d) 80 ATP

138. Krebs' cycle results in the synthesis of:
(a) Glucose and ATP (b) Fumaric acid
(c) Lactic acid (d) Pyruvic acid

139. In anaerobic respiration one of the following occurs as the final product:
(a) Phosphoglyceraldehyde is converted to acetyl CoA
(b) Phosphoglyceraldehyde is converted to pyruvic acid
(c) Phosphoglyceraldehyde is converted to acetic acid
(d) Data insufficient

140. Which of the following observations most strongly support the view that mitochondria contain electron transfer enzymes aggregated into compact associations?
(a) A contractile protein capable of utilizing ATP has been obtained from mitochondria
(b) Mitochondria have a highly folded inner wall
(c) Disruption of mitochondria yields membrane fragments which are able to synthesize ATP
(d) Mitochondria in animal embryes have a tendency to concentrate in cells which are to become part of locomotory structures

141. Largest amount of phosphate bond energy is produced in the process of respiration during:
(a) Anaerobic respiration (b) Glycolysis
(c) Krebs' cycle (d) None of these

*142. Synthesis of ATP in mitochondria requires:
(a) NADP (b) FMN
(c) Oxygen (d) Pyruvic acid

143. Which 5- carbon organic acid of the Krebs' cycle is a key compound in the N_2 metabolism of a cell?
(a) Citric acid (b) Fumaric acid
(c) Oxalosuccinic acid (d) α-Ketoglutaric acid

144. The process of oxidative phosphorylation takes place in: (CMC Vellore 2003)
(a) Chloroplast (b) Ribosomes.
(c) Mitochondria (d) Cell wall

145. During ATP synthesis electron pass through:
(a) Cytochromes (b) Water
(c) O_2 (d) CO_2

146. Krebs' cycle involves the formation of:
(a) Lactic acid from glucose
(b) Change of pyruvic acid to energy transformation
(c) Pyruvic acid from glucose
(d) ATP from ADP

147. When a molecule of pyruvic acid is subjected to anaerobic oxidation and forms lactic acid there is:
(a) Gain of 4 ATP molecules
(b) Gain of 2 ATP molecules
(c) Loss of 3 ATP molecules
(d) Loss of 6 ATP molecules

148. In respiration pyruvic acid is:
(a) Broken down into a two-carbon fragment and carbon dioxide
(b) A result of protein breakdown
(c) Formed only when oxygen is available
(d) One of the product of Krebs' cycle

149. Krebs' cycle is also known as:
(a) Oxidative phosphorylation
(b) Glycolysis
(c) Tricarboxylic acid cycle
(d) Photophosphorylation

150. How many ATP equivalents are produced by its oxidation of succinate into fumarate?
(a) 1 ATP (b) 2 ATP
(c) 3 ATP (d) 4 ATP

151. The importance of Krebs' cycle is:
(a) Production of auxins
(b) Production of amino acids
(c) Production of acetyl CoA
(d) Production of ATP molecules

152. Pentose phosphate pathway, an alternative pathway of respiration was elucidated by:
(a) Warburg (b) Dickens
(c) Horecker (d) Blackman

153. Respiration and photosynthesis both requires:
(a) Organic fuel (b) Cytochrome
(c) Sunlight (d) Energy from carbon bonds

154. Krebs' cycle starts with the formation of six carbon compound by a reaction between:
(a) Malic acid and acetyl coenzyme
(b) Oxaloacetic acid and acetyl coenzyme
(c) Succinic acid and pyruvic acid
(d) Fumaric acid and pyruvic acid

155. Hexose monophosphate shunt is:
(a) A set of reactions that bypasses the glycolytic and Krebs' cycle routes for glucose oxidation in the cell
(b) Conversion of glucose into pyruvic acid
(c) The sum of all chemical transformations
(d) A process by which new products are synthesized

156. Mineral activator needed for the enzymes carboxylase of TCA cycle is:
(a) Mg (b) Fe
(c) Mo (d) Mn

157. If the naked pea seeds are kept in four respiratory flasks, they would germinate best if its flask contains:
(a) Carbon dioxide (b) Oxygen
(c) Hydrogen (d) Nitrogen

158. Enzymes of glycolysis are found in: (CPMT 1993)
(a) Mitochondria (b) Golgi-apparatus
(c) Cytoplasm (d) Glyoxysomes

*159. Most of the energy in the cell is liberated by oxidation of carbohydrates when:
(a) Glucose is converted into alcohol and CO_2
(b) Sugar is converted into pyruvic acid
(c) Pyruvic acid is converted into CO_2 and H_2O
(d) Pyruvic acid is converted into CoA

160. In hexose monophosphate shunt, the number of CO_2 molecules evolved is: (AIIMS 1990)
(a) Same as in glycolysis (b) Less than glycolysis
(c) More than glycolysis (d) Much lesser than glycolysis

161. Why do fishes in an aquarium thrive better if green plants are growing there because they?
(a) Inhale oxygen released by green plants
(b) Inhale carbon dioxide released by green plants
(c) Can feed on them
(d) Like green surroundings

162. Pyruvic acid has .... carbon atoms: (CPMT 1993)
(a) 2 (b) 3
(c) 4 (d) 5

163. If the temperature is increased above 35°C:
(a) Rate of decline of respiration will be earlier than decline of photosynthesis
(b) Rate of decline of photosynthesis will be earlier than decline of respiration
(c) Both decline simultaneously
(d) Both do not show any fixed pattern

164. During 24 hours there is a time when plants neither give O_2 nor CO_2. This is the time of:
(a) Night (b) Day light
(c) Twilight (d) None of these

165. Cut surfaces of fruits and vegetables often become dark because:
(a) Dirty knife makes it dark
(b) Oxidation of tannic acid in the presence of trace of iron from the knife makes it dark
(c) Dust of the air makes it dark
(d) None of the above

166. Life without air is: (CBSE 1993)
(a) Impossible (b) Anaerobic
(c) Reductions (d) Free from oxidative damage

167. Respiratory rate in an organism is:
(a) Increased by a rise in temperature
(b) Decreased by a rise in temperature
(c) Remains unaffected by temperature
(d) None of the above

168. Succinyl CoA is related to:
(a) Krebs' cycle (b) Calvin cycle
(c) Glycollate cycle (d) HMP cycle

169. High temperature does not affect the dry seeds as much as they affect germinating seeds because:
(a) Hydration makes the enzyme more sensitive to temperature
(b) The seedlings are tender
(c) Dry seeds are hard and therefore are resistant to heat
(d) Dry seeds have more reserve food

170. The cut surface of an apple fruit turn brown when in contact with air. If the cut apple is dipped in ascorbic acid (Vitamin C solution), browning does not occur. This is because ascorbic acid:
(a) Overcomes cell injury caused by cutting
(b) Inhibits activity of polyphenol oxidase (PPO)
(c) Prevents release of polyphenol from damaged cells
(d) Prevents drying of cut surface

171. Aerobic respiration of glucose produces energy:
(a) 637 kcal (b) 640 kcal
(c) 673 kcal (d) 693 kcal

172. In oxidation of one molecule of glucose during respiration, 36 molecules of ATP are liberated as follows: (CBSE 1991)
(a) 2 ATP molecules outside the mitochondria and 34 ATP molecules inside the mitochondria
(b) All the 36 ATP molecules inside the mitochondria
(c) 2 ATP molecules during glycolysis and 34 ATP molecules during Krebs' cycle
(d) 2 ATP molecules during glycolysis and 34 ATP molecules during respiratory chain

173. Which among the following is the most appropriate reason for storing green coloured apples at low temperatures?
(a) The rate of photosynthesis is reduced
(b) The rate of respiration is reduced
(c) The rates of photosynthesis and respiration are reduced
(d) Respiration and photosynthesis are completely inhibited

174. During respiration, 38 ATP molecules per glucose molecule are produced in respiratory chain, 22 molecules of these 38 ATP molecules are produced from $NADH_2/FADH_2$ produced during: (CBSE 1993)
(a) Embden–Meyerhof pathway
(b) Oxidative decarboxylation
(c) Krebs' cycle
(d) Respiratory chain itself

175. In cyanides, azides and carbon monoxide, the rate of respiration:
(a) Decreases (b) Increases
(c) Remains the same (d) None of these

176. A reduction of NADP to $NADPH_2$ is associated with:
(a) EMP (b) HMP
(c) Calvin cycle (d) Glycolysis

177. There are 4 plants each kept in a flask containing one of the following gases. In which one of the following the plant will not respire?
(a) Nitrogen (b) Oxygen
(c) Carbon dioxide (d) Data insufficient

178. How many molecules of $NADH_2$ are produced from each molecule of ketoglutarate under aerobic conditions?
(a) One (b) Two
(c) Four (d) Eight

*179. When 100% carbon is oxidized to CO_2, the efficiency of such a respiration is:
(a) 40% (b) 60%
(c) 90% (d) 100%

180. Which of the scientific paper would you assign to plant physiology?
(a) Evergreen forests of India
(b) Embryo culture of plants
(c) Respiratory activities in plants
(d) Cell and cell division

181. Which of the following respiratory material may show the unit value of R.Q.: (BHU 1991)
(a) Stem of wheat (b) Leaf of barley
(c) Leaf of oat (d) All of these

182. When the NADH$_2$ formed in glycolysis reacts with an inorganic element the nature of respiration is? (Raj. PMT 1992)
(a) Aerobic/oxy respiration (b) Anaerobic respiration
(c) Fermentation (d) Photorespiration

183. Robinson's ester is:
(a) Glucose 1,6-diphosphate
(b) Glucose-6-phosphate
(c) Fructose-6-phosphate
(d) None of the above

184. The respiratory substrate yielding maximum number of ATP molecules among the following is: (CBSE 1994)
(a) Glycogen (b) Amylase
(c) Ketogenic amino acid (d) Glucose

185. The potato growing in hilly areas is bigger in size due to:
(a) High rate of photosynthesis at high altitude
(b) Low rate of respiration at high altitude
(c) Due to formation of more fat
(d) None of the above

186. Salt respiration is also called as:
(a) Anion respiration (b) Cation respiration
(c) Photorespiration (d) None of these

187. R.Q. of germinating castor seed is: (BHU 1995)
(a) 1 (b) >1
(c) < 1 (d) 0

188. Plants but not animals can convert fatty acids to sugars by a series of reactions known as the: (CBSE 1994)
(a) Glycolysis (b) Glyoxylate cycle
(c) Photosynthesis (d) Krebs' cycle

189. Upon oxidation of the one mole of pyruvate by mitochondrial respiration, the molecules of ATP generated are: (BHU 1994)
(a) 38 (b) 30
(c) 8 (d) 15

190. In prokaryotes, the mitochondria are absent even then Krebs' cycle takes place. What is the site of Krebs' cycle in bacteria? (MDAT Bihar 1995)
(a) Ribosomes (b) Nucleoid
(c) Cytoplasm (d) Plasma membrane

191. The organelles involved with photorespiration are: (BHU 1994)
(a) Mitochondria, nucleus and ribosomes
(b) Mitochondria, peroxisomes and chloroplasts
(c) Mitochondria peroxisomes and glyoxysomes
(d) Mitochondria chloroplasts and ribosomes

192. The glycolate metabolism occurs in: (MPPMT 1995)
(a) Lysosomes (b) Ribosomes
(c) Glyoxysomes (d) Peroxisomes

193. Which one of the following does not show photorespiration?
(a) *Saccharum* (b) *Zea*
(c) *Chlorella* alga (d) Both (a) and (b)

194. Biological oxidation in Krebs' cycle involves: (MPPMT 1994)
(a) N$_2$ (b) CO$_2$
(c) O$_2$ (d) SO$_2$

195. Mitochondria supply most of its necessary biological energy through: (MPPMT 1994)
(a) Breaking down of sugar
(b) Oxidizing substrates of TCA cycle
(c) Reducing NADP
(d) Breaking down of protein

196. Which group of the following scientists discovered the EMP pathway of glycolysis? (MPPMT 1995)
(a) Embden, Meyerhof and Parnas
(b) Emerson, Hofman and Peterson
(c) Embden, Morrison and Pitcher
(d) Avery, Mcleod and McCarty

197. Oxidative phosphorylation occurs during the process of: (MPPMT 1994)
(a) Protein synthesis (b) N$_2$ fixation
(c) Respiration (d) Transpiration

198. The hydrogen acceptor in hexose monophosphate shunt is:
(a) NADP (b) TPN
(c) Both (a) and (b) (d) NAD

199. The substrate for photorespiration is: (CPMT 1994)
(a) PGA (b) Glycolate
(c) Glyoxylate (d) Pyruvic acid

200. Sinks are related to: (MPPMT 1997)
(a) Transport of minerals (b) Stomata
(c) Enzymes (d) Phytochrome

201. Krebs' cycle means: (AFMC 1996)
(a) Anaerobic respiration (b) Aerobic respiration
(c) Photosynthesis (d) Transpiration

202. The cell organelle associated with photorespiration is: (MPPMT 1996)
(a) Peroxisome (b) Lysosome
(c) Mesosome (d) Ribosome

203. How many ATP will be produced during the production of molecule of acetyl CoA from one molecule of pyruvic acid? (MPPMT 1996)
(a) 3 ATP (b) 5 ATP
(c) 8 ATP (d) 38 ATP

204. At the end of glycolysis, which one of the following changes takes place? (MPPMT 1996, 2000)
(a) Proteins into glucose (b) Glucose into fructose
(c) Starch into glucose (d) Glucose into pyruvic acid

205. The enzymes which take part in glycolysis are found in: (MPPMT 1996)
(a) Mitochondria
(b) Cytoplasm
(c) Mitochondria and cytoplasm
(d) Vacuoles

206. The importance of Krebs' cycle is in the production of: (MPPMT 1996)

(a) Acetyl CoA (b) Water
(c) ATP (d) ADP

207. The enzyme which converts glucose into glucose-6-phosphate is? **(MPPMT 1996)**
(a) Phosphorylase (b) Phosphatase
(c) Hexokinase (d) Gluco-synthetase

208. Krebs' cycle takes place in: **(MPPMT 1997)**
(a) Mitochondria (b) Ribosome
(c) Chloroplast (d) Golgi bodies

209. Photorespiration is favoured by: **(CBSE 1996)**
(a) Low O_2 and high CO_2
(b) Low light and high O_2
(c) High O_2 and low CO_2
(d) Low temperature and high CO_2

210. Supply ends in transport of solute are: **(MPPMT 1997)**
(a) Green leaves and storage organs
(b) Root and stem
(c) Xylem and phloem
(d) Hormones and enzymes

211. In hollow hearted plants:
(a) Root will die first
(b) Shoot will die first
(c) Root and shoot will die at the same time
(d) Neither root nor shoot will die

212. Which of the following is correct regarding the translocation of substances in vascular tissues of plants? **(CBSE 1991)**
(a) Organic substances, *e.g.*, sugars are transported upward in the xylem
(b) Organic substances move up and down in phloem
(c) Salts and other inorganic substances move downward only through the xylem
(d) Inorganic substances move upward only through the phloem

*213. The term 'apoplast' and 'symplast' were used at first by: **(AMU 1996; CET Chandigarh 1997)**
(a) Dixon (b) Clark
(c) Munch (d) Fischer

214. What is the last substrate to be used in respiration? **(AMU 1993)**
(a) Glucose (b) Fats
(c) Organic acid (d) Proteins

215. Meaningful girdling (ringing) experiments cannot be performed with sugar cane plant: **(CBSE 1992)**
(a) Its stem surface is covered with a waxy deposit
(b) Its stem is relatively thin
(c) Its phloem is situated interior to its xylem
(d) Its vascular bundles do not present useful arrangement

216. During glycolysis ATP and Mg^{2+} coenzymes function: **(AIIMS 1992)**
(a) For phosphoglucoisommerase
(b) For glucokinase
(c) For pyruvic kinase
(d) For phosphoglyceraldehyde -3-phosphate dehydrogenase

217. In Krebs' cycle, the conversion of succinyl CoA to succinic acid and requires: **(AMU 1992)**
(a) Acetyl CoA + GDP + ip
(b) CoA + GTP + ip
(c) Acetyl CoA + GTP + ip
(d) GDP + ip

218. A girdled tree may survive for sometime but will eventually die because: **(BHU 1994)**
(a) Water will not move upward
(b) Water will not move downward
(c) Sugars and other organic materials will not move downward
(d) Sugars and other organic materials will not move upward

219. Movements of solutes in the phloem is mainly: **(Pondicherry 1997)**
(a) Acrobetal (b) Lateral
(c) Basipetal (d) Lateral-acropetal

220. The respiration of young maturing seeds is quite high but as water content decreases during further maturation, respiration: **(DPMT 1997)**
(a) Remains high (b) Stops completely
(c) Increases steadily (d) Decreases steadily

221. R.Q. value of 4 may be expected for the complete oxidation of which one of the following? **(Pondicherry 1996)**
(a) Glucose (b) Malic acid
(c) Oxalic acid (d) Tartaric acid

222. The food products are kept in cold storage or under refrigeration because: **(MPPMT 1997)**
(a) It becomes very tasty
(b) Can be used in off season
(c) Food products maintain their freshness, longivity, taste, etc., due to least respiration
(d) They remain very cool

223. Protein is mostly the respiratory substrate in: **(Pondicherry 1997; DPMT 1997)**
(a) Protoplasmic respiration
(b) Floating respiration
(c) Anaerobic respiration
(d) Respiration of oily seeds

224. Fermentation is anaerobic production of: **(CBSE 1996)**
(a) Protein and acetic acid
(b) Alcohol, lactic acid or similar compounds
(c) Ethers and acetones
(d) Alcohol and lipoproteins

225. End products of fermentation are: **(CBSE 1997; Pb. PMT 1997)**
(a) O_2 and ethyl alcohol (b) O_2 and acetaldehyde
(c) CO_2 and ethyl alcohol (d) CO_2 and acetaldehyde

226. Maximum calories are produced by: **(AMU 1996)**
(a) Fats (b) Carbohydrates
(c) Proteins (d) Vitamins

227. In Krebs' cycle FAD participates as electron acceptor during conversion of: **(CBSE 1997; Manipal 1991)**
(a) Succinyl CoA to succinic acid
(b) α-ketoglutarate to succinyl CoA

(c) Succinic acid to Fumaric acid
(d) Fumaric acid to Malic acid

228. Anaerobic process after glycolysis is called: (AFMC 1997)
(a) TCA (b) Calvin cycle
(c) Krebs' cycle (d) Fermentation

229. The high energy phosphate produced in Krebs' cycle when succinyl CoA is converted into succinate is: (Pondicherry 1996)
(a) ATP (b) CTP
(c) GTP (d) VTP

230. The process of release of energy by chemical breakdown of glucose in the absence of oxygen is termed as: (AMU 1997; Manipal 1997)
(a) Aerobiosis (b) Anaerobiosis
(c) Ornithine cycle (d) Deamination

231. Fermentation is represented by the equation: (MPPMT 1996; AFMC 2002)
(a) $C_6H_{12}O_6 \longrightarrow 6CO_2 + 6H_2O + 673$ kcal
(b) $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + 18$ kcal
(c) $6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6H_2O + 6O_2$
(d) $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$

232. Heat energy of plants is measured in: (AMU 1996)
(a) Grams (b) Pounds
(c) Decibels (d) Calories

233. Anaerobic respiration takes place in: (AMU 1996; Manipal 1997; MPPMT 2002)
(a) Ribose (b) Nucleus
(c) Cytoplasm (d) Vacuole

234. Enzyme α-ketoglutarate dehydrogenase brings about: (AMU 1997)
(a) Oxidation only
(b) Decarboxylation only
(c) Reduction only
(d) Oxidation and decarboxylation

235. What would happen if $NADH_2$ is oxidised to form water in a single step? (MPPMT 1996)
(a) 3 ATP produced
(b) Most of the energy is wasted in heat form
(c) 5 ATP produced
(d) Cell would burn

236. Lactic acid fermentation is characterised by lack of production of: (AIIMS 1996; Pb. PMT 1997)
(a) ATP (b) $NADH_2$
(c) CO_2 (d) CO_2 and $NADH_2$

*237. The number of oxygen molecules utilized during aerobic oxidation of one molecule of pyruvate is: (CET Chandigarh 1997; DPMT 1997)
(a) 12 (b) 6
(c) 5 (d) 3

238. The major link in transfer of chemical energy is ATP-ADP system was first described by Lipmann in: (Pb. PMT 1997)
(a) 1940 (b) 1950
(c) 1960 (d) 1970

239. The enzyme that interconnects the glycolysis with Krebs' cycle: (CPMT 1997, MPPMT 2001)
(a) CoA [✓ (b) Acetyl CoA]
(c) CAMP (d) All of these

240. Food is transported in plants mostly as: (CPMT 1998; BHU 1999)
(a) Glucose (b) Fructose
[✓ (c) Sucrose] (d) Starch

241. Anaerobic respiration after glycolysis is called: (AFMC 1998)
(a) Fragmentation (b) Restoration
(c) Multiplication (d) Fermentation

242. Last (ultimate) electron receptor in aerobic respiration is: (AFMC 1998, 2002; AIIMS 1999)
(a) CO_2 [✓ (b) O_2]
(c) H_2 (d) NADH

243. Maximum usable energy per mole of glucose will be produced during: (CBSE 1999)
(a) Aerobic respiration of germinating seeds
(b) Fermentation into ethanol by yeast
(c) Production of methanol by enteric bacteria
(d) Glycolysis in the skeletal muscle of a sprinter performing a hundred metre dash

*244. Starting point of photorespiration in C-4 plants is: (CPMT 1999)
(a) Glycerate (b) Glycolate
(c) Glyoxylate (d) None of these

245. Electron transport chain occurs as: (CPMT 1999)
(a) Outer membrane of mitochondria
(b) Inner membrane of mitochondria
(c) Matrix of mitochondria
(d) None of the above

246. Transport of organic food through phloem is called: (CPMT 1999)
(a) Transpiration (b) Translocation
(c) Ascent of sap (d) None of these

247. Which of the following is formed during respiration? (MPPMT 1999)
(a) O_2 (b) CO_2
(c) NO_2 (d) SO_2

248. The direction of the conduction of food through phloem is: (MPPMT 1999)
(a) From below upwards
(b) From top to bottom
(c) From leaves to roots
(d) Phloem never conducts food

249. The pyruvic acid formed in glycolysis is oxidized to CO_2 and H_2O in a cycle called: (MPPMT 1999)
(a) Calvin cycle (b) Hill reaction
(c) Krebs' cycle (d) Nitrogen cycle

250. During anaerobic respiration yeast and bacteria, liberate: (AFMC 2000)
(a) O_2 (b) CO_2
(c) N_2 (d) S

*251. Which of the following cells do not respire? **(AFMC 2000)**
(a) Epidermal cell [✓ (b) Cork cell]
(c) RBC (d) Sieve tube cell

252. R.Q. is more than one in case of: **(MPPMT 2000)**
(a) Fat (b) Fructose
(c) Glucose [✓ (d) Organic acid]

253. The reactions of glycolysis (EMP) occur in: **[CET Karnataka 2000; CPMT 2001; BCECE (P.T. Exam.) 2001; Orissa JEE 2002]**
(a) Mitochondria (b) Ribosomes
[✓ (c) Cytoplasm] (d) Golgi complex

254. After glycolysis, pyruvate dissociates into CO_2 and H_2O in: **(CPMT 2001)**
(a) Cytoplasm [✓ (b) Matrix of mitochondria]
(c) Perimitochondrial space (d) Cristae

255. Ethyl alcohol and lactic acid are: **(Manipal 2001)**
[✓ (a) Products of anaerobic respiration]
(b) Products of fermentation
(c) Products of aerobic respiration
(d) None of the above

256. Loading of phloem is related to: **(CBSE 2001)**
[✓ (a) Increase of sugar in phloem]
(b) Elongation of phloem cell
(c) Separation of phloem parenchyma
(d) Strengthening of phloem fibre

257. Most of enzymes which participate in Krebs' cycle are found in: **(MPPMT 2001)**
[✓ (a) Matrix of mitochondria]
(b) Inner membrane of mitochondria
(c) Outer membrane of mitochondria
(d) Stroma of chloroplast

258. R.Q. of sprouting potato tubers will be: **(CET Karnataka 2002)**
(a) < 1 [✓ (b) 1]
(c) 0 (d) > 1

259. Which of the following takes place in Krebs' cycle? **(Raj. PMT 2001)**
(a) Complete oxidation of acetyl CoA into CO_2 and H_2O
(b) Complete reduction of acetyl CoA into CO_2 and H_2O
[✓ (c) Complete oxidation of acetyl CoA into CO_2 and H_2O with electron transport]
(d) Complete oxidation of citric acid into H_2O

260. Largest amount of phosphate bond energy is produced in the process of respiration during: **(BHU 2002)**
[✓ (a) Glycolysis] (b) Fermentation
(c) Krebs' cycle (d) Anaerobic respiration

261. Photorespiration is the characteristic of: **(BHU 2002)**
(a) CAM plants [✓ (b) C-3 plants]
(c) C-4 plants (d) C-2 plants

*262. Glycolate accumulates in chloroplasts when there is: **(BHU 2002)**
[✓ (a) Low CO_2] (b) High CO_2
(c) Bright light (d) Low temperature

263. The movement of materials through the vascular tissue of plants is called: **(BHU 2002)**
(a) Transpiration [✓ (b) Translocation]
(c) Transcription (d) Transduction

264. Glycolysis is found in cytoplasm of virtually all types of aerobic/anaerobic cells. In this process, glucose is converted into a compound which is: **(AIIMS 2002; MPPMT 2002)**
(a) PEP [✓ (b) Pyruvic acid]
(c) Acetyl CoA (d) Citric acid

265. Glycolysis is a: **(AFMC 2002)**
(a) Redox process (b) Aerobic process
(c) Oxidative process (d) Reductive process

*266. When malic acid is the respiratory substrate: **(EAMCET 2002)**
[✓ (a) The amount of CO_2 released is more than the O_2 consumed]
(b) The amount of CO_2 released is less than the O_2 consumed
(c) The amount of CO_2 released is equal to O_2 consumed
(d) CO_2 is not released

267. Respiratory quotient of which diet is less than unity? **(Raj. PMT 2002)**
(a) Carbohydrate [✓ (b) Fats]
(c) Organic acid (d) Sugar

268. 6 molecules of glucose + 6 molecules of O_2 and 38 ADP combined to form $6H_2O$, $6CO_2$ and: **(Raj. PMT 2002)**
[✓ (a) 38 ATP] (b) 28 ATP
(c) 38 ADP (d) 28 ADP

269. Phloem conducts food by: **(CPMT 2003)**
[✓ (a) Perforated sieve plates] (b) Bast fibres
(c) Xylem parenchyma (d) Xylem fibres

270. Respiratory quotient is less than one for: **(BHU 2003)**
(a) Banana (b) Potato
(c) Citrus fruits [✓ (d) Castor seeds]

271. Mitochondria is the site for: **(Orissa JEE 2003)**
(a) Calvin cycle [✓ (b) Krebs' cycle]
(c) Hill reaction (d) Glycolysis

272. In anaerobic respiration pyruvic acid in muscle forms: **(DPMT 2003)**
(a) Alcohol (b) Lactic acid
(c) Acetaldehyde (d) Acetyl coenzyme

273. Which of the following is required for conversion of 3-PGAL and dihydroxy acetone phosphate to fructose 1-6 diphosphate? **(BV Pune 2003)**
(a) Hexokinase (b) Phosphatase
(c) Aldolase (d) Transketolase

274. Which of the following is produced during Krebs' cycle? **(BV Pune 2003)**
(a) Acetic acid (b) Acetyl co-enzyme A
(c) Lactic acid [✓ (d) Citric acid]

275. Photorespiration is favoured by: **(BV Pune 2003)**
[✓ (a) High O_2 and low CO_2] (b) Low temp. and high O_2
(c) Low O_2 and high CO_2 (d) Low light and high O_2

276. In which of the following, the two names refer to one and the same thing? — **(CBSE 2003)**
(a) Krebs' cycle and Calvin cycle
(b) Citric acid cycle and Calvin cycle
(c) Tricarboxylic acid cycle and urea cycle
[✓ (d) Tricarboxylic acid cycle and citric acid cycle]

277. In alcohol fermentation: **(CBSE 2003)**
(a) There is no electron donor
(b) Oxygen is the electron acceptor
[✓ (c) Triose phosphate is electron donor while acetaldehyde is electron acceptor]
(d) Triose phosphate is electron donor while pyruvic acid is electron acceptor

278. Which of the following is wrong in relation to photorespiration? **(CBSE 2003)**
(a) It occurs in chloroplasts
(b) It occurs in day time only
(c) It is a characteristic of C_3 plants
[✓ (d) It is a characteristic of C_4 plants]

*279. The number of glucose molecules required to produce 38 ATP molecules under anaerobic conditions by any yeast cell is: **(PMET Punjab 2003)**
(a) 1 (b) 2
[✓ (c) 19] (d) 38

1 glucose – 2 ATP in yeast

280. Glycolysis takes place in: **(AFMC 2003)**
(a) All living cells (b) Eukaryotic cells only
(c) Prokaryotic cells only [✓ (d) None of these]

281. Photorespiration in C_3 plants starts from: **(AIIMS 2003)**
(a) Phosphoglycerate [✓ (b) Phosphoglycolate]
(c) Glycerate (d) Glycine

282. Which of the following is utilized first in respiration? **(Manipal 2003)**
[✓ (a) Hexose] (b) Sucrose
(c) Protein (d) Fat

283. During anaerobic respiration in yeast: **(Manipal 2003)**
(a) H_2O, CO_2 and energy are the only end products
(b) H_2S, $C_6H_{12}O_6$ and energy are the end products
[✓ (c) CO_2, C_2H_5OH and energy are the end products]
(d) Water and CO_2 are the end products

284. Which is the first step of aerobic respiration? **(MGIMS Wardha 2003)**
(a) Citric acid cycle [✓ (b) Glycolysis]
(c) Electron transport (d) Oxidative phosphorylation

285. The end product of glycolysis is: **(CMC Vellore 2003)**
(a) OAA (oxaloacetic acid)
(b) G-3-P (glyceraldehyde-3-phosphate)
(c) PGA (phosphoglyceric acid)
[✓ (d) Pyruvic acid ($CH_3COCOOH$)]

ANSWERS

1—c	2—b	3—c	4—c	5—b	6—d	7—a	8—c	9—b	10—d	11—c	12—c
13—d	14—b	15—b	16—b	17—d	18—c	19—b	20—c	21—a	22—b	23—d	24—b
25—b	26—a	27—c	28—c	29—b	30—c	31—b	32—d	33—b	34—c	35—c	36—d
37—c	38—d	39—c	40—b	41—c	42—c	43—b	44—c	45—d	46—b	47—c	48—c
49—c	50—c	51—a	52—d	53—a	54—a	55—d	56—d	57—b	58—c	59—c	60—b
61—c	62—c	63—c	64—b	65—b	66—a	67—a	68—b	69—b	70—a	71—c	72—a
73—a	74—a	75—c	76—c	77—b	78—a	79—b	80—c	81—b	82—b	83—b	84—a
85—a	86—c	87—b	88—c	89—b	90—c	91—c	92—c	93—b	94—a	95—c	96—a
97—a	98—b	99—b	100—b	101—b	102—b	103—d	104—b	105—a	106—d	107—b	108—c
109—b	110—b	111—d	112—c	113—c	114—c	115—b	116—b	*117—b	118—d	119—a	120—c
121—b	122—b	123—c	124—b	125—b	126—a	127—d	128—c	129—b	130—b	131—c	132—a
133—a	134—d	135—d	136—c	137—d	138—b	139—d	140—c	141—c	142—c	143—d	144—c
145—a	146—b	147—d	148—a	149—c	150—b	151—d	152—a	153—b	154—b	155—a	156—a
157—b	158—c	159—c	160—c	161—a	162—b	163—b	164—c	165—b	166—b	167—a	168—a
169—a	170—b	171—c	172—a	173—b	174—c	175—a	176—b	177—d	178—a	179—a	180—c
181—d	182—a	183—b	184—d	185—b	186—a	187—c	188—b	189—d	190—d	191—b	192—d
193—d	194—c	195—b	196—a	197—c	198—a	199—b	200—a	201—b	202—a	203—a	204—d
205—b	206—c	207—c	208—a	209—c	210—a	211—d	212—b	213—c	214—c	215—d	216—b
217—d	218—c	219—c	220—d	221—c	222—c	223—a	224—b	225—c	226—a	227—c	228—d
229—c	230—b	231—b	232—d	233—c	234—d	235—a	236—d	237—c	238—a	239—b	240—c
241—d	242—b	243—a	244—d	245—b	246—b	247—b	248—c	249—c	250—b	251—b	252—d
253—c	254—b	255—a	256—a	257—a	258—b	259—c	260—a	261—b	262—a	263—b	264—b
265—d	266—a	267—b	268—a	269—a	270—d	271—b	272—b	273—c	274—d	275—a	276—d
277—c	278—d	279—c	280—d	281—b	282—a	283—c	284—b	285—d			

EXPLANATION OF SELECTED QUESTIONS (*)

1. As respiration is characteristic of living organisms or cells hence it is called vital process.

3. Enzymes of glycolysis are present in cytosol (Cytoplasm—organelles).

7. There are five oxidation steps in aerobic respiration (one in intermediate step and 4 in Krebs' cycle). These are catalyzed by dehydrogenases.

16. Respiratory enzymes in bacteria are present on plasma membrane or mesosomes.

36. Photorespiration is a wasteful phenomenon and no ATP and $NADH_2$ formation occurs here.

40. As respiratory substrate in photorespiration is glycollic acid (2C-compound), hence called C-2 cycle.

44. Cytochromes (electron carriers) were discovered by McMunn.

49. As one ATP contains 7.3 kcal of energy and hence for 2800 kcal, 384 ATP molecules are required.

51. Glucose is the chief respiratory substrate and thus gives energy on oxidation instantly.

76. ATP synthesis in mitochondria (oxidative phosphorylation) occurs in F_1 particles or oxysomes present on cristae.

93. Fats give maximum energy on oxidation. As palmitic acid is a fatty acid produced by hydrolysis of fat, hence produces maximum number of ATP on oxidation.

98. If volume of CO_2 liberated during respiration is more than volume of O_2 used, so R.Q. will be more than one and hence respiratory substrate is organic acid.

104. In glycolysis, 4 ATP molecules are produced and 2 are used, hence net gain of ATP is 2.

114. As respiratory substrate $C_{39}H_{72}O_6$ is poorer in oxygen as compared to C and H, hence more O_2 will be required to oxidise it. So value of R.Q. will be less than one (0.718).

118. In intermediate step of aerobic respiration, pyruvic acid is oxidatively decarboxylated to form acetyl CoA.

134. Pyruvate dehydrogenase (a multienzyme complex) is used for conversion of pyruvic acid to acetyl CoA.

142. Synthesis of ATP in mitochondria occurs in presence of O_2.

159. End product of glycolysis pyruvic acid undergoes complete oxidation into CO_2 and H_2O to release most of the energy.

179. Efficiency of aerobic respiration in 40%.

213. Munch (1930) first of all used the terms apoplast and symplast. Living continuous system comprising cells connected to each other by plasmodesmata (*i.e.*, phloem system with its concentrated food) is called symplast whereas non-living continuous system comprising non-living cells and cell wall of xylem as apoplast.

237. Complete oxidation of one molecule of glucose involves 12 oxidative reactions and each utilizes half O_2 molecule, *i.e.*, total of $6O_2$ (1 in glycolysis and 5 further).

244. Photorespiration is absent in C-4 plants.

251. Cork cells are dead cells and hence do not respire.

262. Glycolate is respiratory substrate in photorespiration, which is formed in high O_2/CO_2 ratio under the influence of RuBP-oxygenase in chloroplast.

266. In case of malic acid (organic acid), amount of CO_2 released is more than O_2 consumed and thus value of R.Q. is more than 1.

279. As one glucose molecule produces 2 ATP molecules for yeast under anaerobic conditions, hence, 19 molecules of glucose are required to produce 38 ATP molecules.

25

Plant Physiology (V)

SPECIAL MODES OF NUTRITION, PHYSIOLOGY OF FLOWERING, GROWTH, GROWTH HORMONES, PLANT MOVEMENTS

- ☐ **Special modes of nutrition :** Saprophytes, Symbiotic plants, Parasites, Insectivorous plants
- ☐ **Physiology of flowering :** Photoperiodism, Vernalization
- ☐ **Growth :** Growth, phases of growth, course of growth, measurement of growth
- ☐ **Growth hormones :** Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid, Morphactins, Wound hormone
- ☐ **Plant Movements :** Movements of locomotion, Movements of curvature

SPECIAL MODES OF NUTRITION

Generally plants are autotrophic in their mode of nutrition, but there are some examples which are heterotrophic in their mode of nutrition. These plants are unable to manufacture their own food due to lack of chlorophyll or some other reasons, *e.g.*, some bacteria, fungi, some bryophytes, pteridophytes and few angiospermic plants also, but special mention is of angiospermic plants. There are 4 special modes of nutrition:

(1) Saprophytes (2) Symbiotic plants
(3) Parasites (4) Insectivorous plants.

1. Saprophytes

These plants live upon dead organic matter and are responsible for conversion of complex organic substances into simple inorganic substances (minerals), *e.g.*, some bacteria, some fungi, few algae (*Polytoma*), few bryophytes (*Buxbaumia, Hypnum* and *Splanchnum*), few pteriophytes (like *Botrychium*) and some angiosperms also.

Important angiospermic saprophytes are:

(i) *Neottia* (Bird's nest orchid) : Grows in humus rich soil and having **endotrophic mycorrhiza.**

(ii) *Monotropa* (Indian pipe) : Grows in humus rich soils below pine forests. It is also having endotrophic mycorrhiza.

(iii) *Corallorhiza.*

(iv) *Moneseis.*

2. Symbiotic plants

Here there is association between 2 dissimilar plants or organisms and both of them are **mutually benefitted** by each other.

(Term Symbiosis was given by **De Bary**).

e.g., **(i) Lichens** → Algal partner + Fungal partner.

(ii) Mycorrhiza or Mycorrhizal association : Association between roots of higher plants and fungal hyphae is known as mycorrhiza. This was discovered by **Frank** (1885).

(iii) Root nodules of legumes : Inside these nodules, *Rhizobium* bacteria are present, which symbiotically fix atmospheric N_2.

- o **Leghaemoglobin,** a red pigment is found in cytoplasm of cortical cells of roots of legumes (root nodules). It combines with O_2 and thus is efficient O_2 scavenger. It also provides a slow supply of O_2 at lower concentration, which is favourable for activity of **nitrogenase** enzyme in nitrogen fixation.

3. Parasites

Parasite is an organism which lives in **constant association** with some other organism called **host** and obtain its food without killing the host.

Important angiospermic parasites are:

(i) **Total stem parasites,** *e.g., Cuscuta* (dodder or amarbel).

(ii) Partial stem parasites, *e.g., Viscum* (Mistletoe) and *Loranthus.*

(iii) Total root parasites, *e.g., Orobanche* (broom rape), which lives on roots of brinjal, tomato, etc.

- *Rafflessia* (largest flower in the world) was discovered by **Sir Stamford Raffles** from Java. Flower measures about a meter in diameter, smell is like rotten fish, pollination by elephants and found on roots of *Vitis* and *Cissus.*
- *Sapria himalayensis* (largest flower in India), measures 15 cm – 30 cm in diameter.
- *Balanophora.*

(iv) Partial root parasites, *e.g., Santalum* on roots of *Dalbergia, Eucalyptus* and *Albizzia* (siris).

Similarly, *Striga* on roots of sugar cane and *Thesium* on the roots of grasses are other partial root parasites.

4. Insectivorous plants

These plants are autotrophic in their mode of nutrition but they grow in **marshy or muddy soils,** which are generally deficient in nitrogen and in order to fulfil their **nitrogen requirement,** these plants catch small insects. The organs and specially leaves of these plants are modified variously to catch the insects. These plants have **glands secreting proteolytic enzymes** which breakdown complex proteins into simple nitrogenous substances, which inturn are absorbed by these plants.

- Insectivorous plants are example of **predation** (*i.e.,* first killing and then eating).

Important examples of insectivorous or carnivorous plants are:

(i) *Nepenthes* (Pitcher plant) : It is found in **Assam and Meghalaya** (*i.e., N. khasiana*).

Here leaf lamina is modified to form a pitcher (upto 30 cm long) and leaf apex forms a coloured lid. Lower part of pitcher contains spinous structures and glands.

(ii) *Drosera* (Sundew plant) : Here leaf has tentacles, at the apices of which sticky drops are present, which shine as dew in light. These tentacles catch the insects.

(iii) *Utricularia* (Bladderwort) : It is small free floating, rootless hydrophyte with dissected leaves and some of the leaf segments are modified to form small bladders to catch the insects.

(iv) *Dionaea* (Venus fly trap).

(v) *Pinguicula* (Butterwort).

(vi) *Sarracenia* (Devil's boot) : Having pitcher as in *Nepenthes.*

(vii) *Aldovanda* (Water flea trap).

(viii) *Cephalotus* (Fly catcher plant), etc.

PHYSIOLOGY OF FLOWERING

Flower formation is a transitional phase in the life cycle of plant. During flowering, vegetative shoot apex is converted into reproductive shoot apex.

The physiological mechanism for flowering is controlled by 2 factors:

(I) Photoperiod or light period, *i.e.,* **Photoperiodism.**

(II) Low temperature, *i.e.,* **Vernalization.**

I. Photoperiodism

Plants in order to flower require a particular day length or light period called photoperiod and response of the plants to photoperiod in terms of flowering is called photoperiodism.

Or

Photoperiodism is the **response to duration and timings** of light and dark periods.

- Photoperiodism was first studied by **W.W. Garner and H. A. Allard** (1920).

They observed that tobacco mutant, *i.e.,* 'Maryland mammoth' flowered at different times at different places. After controlling other factors like temperature, nutrition, etc., they reported that it was the length of the day which affected flowering. They gave the term photoperiod to favourable day length for each plant.

There are following 5 photoperiodic classes of plants:

(i) Short day plants (SDP's) : These flower in photoperiods less than critical day length, *e.g., Nicotiana tabacum, Glycine max* (Soybean), *Xanthium strumarium* (Cocklebur), *Canabis sativa, Coleus,* etc. Further these plants require **long uninterrupted dark period** and hence are called **long night plants.**

(ii) Long day plants (LDP's) : These flower in photoperiod more than critical day length, *e.g., Hyocyamus niger* (Henbane), radish, *Beta,* spinach, *Plantago,* etc.

(iii) Day neutral plants : They flower in any photoperiod, *e.g.,* tomato, maize, cucumber, etc.

(iv) Short-Long day plants : These are actually long day plants but in their early life, they need short day conditions, *e.g.,* wheat, European rye (*i.e., Secale*).

(v) Long-Short day plants : These are short day plants but require long day conditions initially, *e.g., Bryophyllum, Cestrum nocturnum.*

Critical day length

Is that length of photoperiod above or below which flowering occurs, *e.g., Xanthium* is SDP and its critical day length is 15 hrs, *i.e.,* below 15 hrs flowering will take place.

Similarly, *Hyocyamus niger* is LDP, critical day length is 11 hrs, *i.e.,* above 11 hrs flowering will take place.

- So critical day length is not indicative of type of photoperiodic class of the plants. (it needs further researches).

- Nowadays **dark period** is considered to be more important than photoperiod for flowering.
- **Chailakhyan** (1932), first of all explained, how flowering is affected by light ? Before him phenomenon of **photoinduction** was well known (*i.e.*, continuation of effect of favourable conditions even under unfavourable conditions).

Chailakhyan proposed that under favourable conditions of photoperiod, a stimulus is produced and this stimulus is **hormonal in nature**, *i.e.*, a flowering hormone, **'florigen'** is produced in favourable conditions in plants.

Florigen = Gibberellins + Anthesins (perhaps steroid)

- SDP's contain anthesins and synthesize gibberellic acid for flowering, whereas LDP's contain GA and synthesize anthesins for flowering.

Photoperiodism and quality of light

Green light is inefficient in inducing flowering, blue light induces poor flowering and red light induces best flowering.

Organ of reception of photoperiodic stimulus

Leaves are the organs of reception of photoperiodic stimulus which is experimentally verified by grafting experiments.

- Flowering in a SDP can be inhibited if dark period is broken by a flash of light and red light (660 nm) is most effective in breaking long night into short nights whereas far red light does not break long night into short nights. Further far red light also reverses the adverse effect of red light.
- **Borthwick and Hendricks** (1952) reported a photoreceptive pigment called **'phytochrome'**. It is a **bright blue or bluish green pigment** which was first of all isolated from plasma membrane of alga *Mougeotia*. Phytochrome has a light absorbing or light detecting portion (the **chromophore**) attached to small **protein** of about 1,24,000 daltons. Phytochrome occurs in 2 forms, *i.e.*, P_R and P_{FR} (*i.e.*, red light and far red light absorbing forms) and these 2 forms are **interconvertible**.

$$P_R \underset{\text{Far red light}}{\overset{\text{Red light}}{\rightleftharpoons}} P_{FR}$$

- It is considered that during day time, P_{FR} form accumulates in plants which is inhibitory to flowering in SDP and stimulatory to flowering in LDP.

During night, P_R form accumulates in plants which is stimulatory to flowering in SDP's and inhibitory to flowering in LDP's. If red light is given to SDP during night, P_R is converted into P_{FR}, which inhibits flowering in SDP's but if far red light is given after red light, P_{FR} form again is converted into P_R form, which induces flowering in SDP's.

II. Vernalization

Besides correct photoperiod, some plants require low temperature treatment for flowering. This was first of all reported by **Klippart** (1859).

- Term vernalization (or concept of vernalization) was first given by **T.D. Lysenko** (1928). In colder countries, there are cereals of 2 physiological types, *i.e.*, **winter cereals and spring cereals. Winter cereals** are sown in winter and flower in following summer whereas spring cereals are sown in spring and flower in summer.
- If winter cereal is sown in spring, it shows vegetative growth but does not flower unless it receives low temperature of winter. But winter cereal can be converted into spring cereal by providing artificial low temperature treatment. (*i.e.*, **springification**).
- Term **vernalization** is derived from Latin word, *i.e.*, *Ver*-means **spring** with a suffix (meaning to make), so vernalization means ability of low temperature treatment to convert winter cereal into spring cereal as a result of satisfaction of their low temperature requirement.

Chourd (1960) defined vernalization as, "acceleration of subsequent flowering by low temperature treatment."

Some plants requiring low temperature requirement (vernalization) for flowering are *Secale cereale* (European rye), *Triticum vulgare, Brassica oleracea, Beta vulgaris, Apium* and *Lolium perenne*, etc.

- Site of vernalization is **apical meristem** or all the meristematic cells.

As a result of vernalization, a flowering hormone called **"vernalin"** is formed (reported by **Melchers**), but vernalin has never been isolated.

Devernalization : Once a plant is vernalized, it can be devernalized by exposing the plant to temperature of **30°C** or above. For establishing vernalization, plant should be kept at 20°C for 4–5 days.

Conditions necessary for vernalization

1. Age of the plant : This varies from plant to plant, *e.g.*, in wheat, vernalization is done in germinating seeds. Similarly *Hyocyamus* (Henbane) receives vernalization after 10 days of vegetative growth.

2. Temperature : 1–6°C is the optimum temperature. –6°C is completely noneffective. Similarly, 7°C is also less effective.

3. Duration : $1-1\frac{1}{2}$ months low temperature treatment is necessary in most of the plants.

4. O_2 : As vernalization is aerobic process, so it requires O_2.

5. Water : Proper hydration is necessary for vernalization.

Importance of vernalization

1. Crops can be grown earlier.
2. Plants can be grown in such regions where normally they do not grow.
3. Yield of the plant is increased.
4. Resistance to cold and frost is increased.
5. Resistance to fungal diseases is increased.

GROWTH

Growth is **irreversible change in shape, size and volume, accompanied with increase in dry matter.**

- Growth is a **quantitative change.** Further in growth, anabolic processes exceed catabolic processes or growth is final end product of successful metabolism.
- In unicellular plants, growth is overall and is not restricted to specific regions.

In multicellular plants, growth is restricted to some specific regions called **meristems** and these meristems are of 3 types:

(i) **Apical meristem :** Present at root apex and shoot apex and is responsible for increase in length.

(ii) **Intercalary meristem :** Present at base of nodes or internodes and is also responsible for increase in length.

(iii) **Lateral meristem :** Which divide radially and is responsible for increase in girth or diameter.

Phases of Growth

Cell division → Cell enlargement → Differentiation

Course of Growth

Under favourable conditions in any organ, growth is initially slow, which is called **lag phase**, then it becomes faster called **log phase** or **exponential phase** and then becomes steady or constant called **steady phase.**

This grand period of growth is represented by **Sigmoid curve or S-shaped curve.**

Measurement of Growth

Growth is measured with the help of:

(i) **Auxanometers**
- Arc auxanometer
- Pfeffer's auxanometer

(ii) **Horizontal microscope**

(iii) **Crescograph :** A sensitive apparatus for measuring growth, developed by **Sir J.C. Bose.**

○ (Measurement of growth in root by marking it at equal intervals with India ink was first done by **Sachs**).

GROWTH HORMONES

The term **'Hormone'** was first of all used by **Starling** (1906) in animal physiology for specific organ forming substances, which are secreted by cells in one part of body and produce their effect in other part of body. Circulatory system of plants is not so developed, but still behaviour of certain substances in plants was found to be similar to hormones, which are called plant growth hormones or **phytohormones.**

Thimann defined phytohormone as, 'an organic substance, naturally produced in plant, affecting growth and other functions remote from its place of production and is active in very minute amount.'

○ **Growth regulators**
= Phytohormones (natural) + Synthetic substances

So all phytohormones are growth regulators but all growth regulators are not phytohormones.

Growth hormones or growth regulators are of 2 types:

I. Growth promotors	**II. Growth inhibitors**
e.g., Auxins, Gibberellins (GA) and Cytokinins	*e.g.*, Ethylene, Abscisic acid (ABA)

○ Hormones were originally measured with **bioassays** but nowadays most hormones are measured with **gas chromatography** and **immunoassay techniques.**

Auxins

History of auxins dates back to **Darwin** (1886). He took *Avena* seedling and placed it under a dark chamber with a hole (through which light enters). After sometime the tip bent towards light (hole).

But when the tip was cut, no bending was observed. Therefore, some substances are secreted in tip, due to which bending was there.

Boysen and Jensen (1910) explained that the substances secreted in the tip are soluble in water (gelatin).

Paal (1919) took *Avena* seedling, its tip was cut and then cut tip was placed on half portion. It was covered with completely dark chamber (without hole). Bending was observed in opposite side, where tip was placed. He reported that the substances secreted in the tip are translocated downwards and caused cell elongation in half portion and hence bending was observed in opposite direction.

F.W. Went (1928) further refined this experiment and supported the observations of **Paal.**

○ **F.W. Went** was the first person to name these substances of tip as **Auxins** (Greek *Auxein*—means to grow).

○ **Kogl** and **Haagen Smith** (1931) isolated a substance from **human urine**, *i.e.*, **Auxin-A** and then in 1934, **Auxin-B** from **corn germ oil.**

Re-examination of **human urine** led to discovery of another substance called **Heteroauxin** and it was similar to **IAA** (Indole acetic acid).

Thimann (1936) isolated IAA from *Rhizopus suinus* and then from *Avena* coleoptile and other plants.

So, IAA is a true natural auxin of plants.

(Auxins were first of all discovered from human urine.)

Auxins are the chemical substances which are responsible for elongation of shoot cells.

- o 20,000 tons of *Avena* tips give 1 g of IAA.
- o Auxins predominatly show basipetal movement (from shoot apex to base), however, acropetal movement is also seen (from root to shoot). This is called polar transport of auxins.

Examples of Auxins

(A) **Natural Auxins :** Indole-3-acetic acid (IAA).

Tryptophan (amino acid) is the precursor of IAA and **zinc** is responsible for its synthesis.

(B) **Synthetic or Exogenous Auxins:**

Indole-3-butyric acid (IBA)
Indole-3-propionic acid IPA
Indole pyruvic acid IP
α-Naphthalene acetic acid (NAA)

2,4-D (2,4-dichlorophenoxy acetic acid) and 2, 4, 5-T (2, 4, 5-trichlorophenoxy acetic acid).

Bioassay of Auxins : To test any chemical substance by using living system is called **bioassay**. Important bioassays of auxins are:

(a) **Avena curvature bioassay :** Given by F.W.Went.

(b) **Avena section test.**

Physiological effects of Auxins

1. **Cell enlargement :** Auxins show elongation of cells in shoot.

2. **Cell division :** Auxins induce cell division activity in cambium.

3. **Differentiation :** Auxins induce early differentiation of xylem and phloem in tissue culture experiments.

- o Auxins +2% of sucrose favour differentiation of xylem.
- o Auxins +3% of sucrose favour differentiation of xylem and phloem.
- o Auxins +4% sucrose favour differentiation of phloem.

4. **Root initiation :** In general, **auxins initiate rooting but inhibit the growth of roots.**

- o IBA is the most potent root initiator.
- o Cuttings are made oblique so that all the auxins are accumulated at a point and hence roots are initiated early.

5. **Apical dominance :** Apex inhibits the growth of axillary buds (apical dominance).

If apex is cut, then axillary buds show their growth, *i.e.*, apical dominance is removed.

- o **Thimann and Skoog** reported that IAA (auxin) is responsible for apical dominance.
- o This practice of removal of apical dominance is applied in tea gardens, hedges, rose gardens, etc.

6. **Fruit formation :** Auxins enhance the size of carpel and hence earlier fruit formation.

7. **Senescence :** Application of auxins retards the process of senescence (last degradative phase).

8. **Abscission :** Application of auxins retards the abscission of leaves, fruits, branches, etc.

9. **Parthenocarpy :** Auxins induce parthenocarpic development of fruits and such fruits are **'seedless'**. (Development of fruit without fertilization is called parthenocarpy). The term parthenocarpy has been derived from *parthenos*—meaning **virgin.**

- o Auxins are applied in lanolin paste on stigma for inducing parthenocarpy.

10. **Sex expression : Heslop–Harrison** (1965) in *Canabis sativa* and other plants reported that auxins induce **faminization**, *i.e.*, on male plant, female flowers are produced.

11. **Weed control : 2,4-D** is a famous **herbicide** or weedicide (especially kills broad leaved weeds). It kills weeds perhaps by over stimulated root growth.

12. **Phototropism and geotropism :** Auxins are responsible for these phenomena (Cholodny-Went theory).

- o Mixture of 2,4–D and 2, 4, 5, –T (dioxin) is given the name **'Agent orange'** which was used by U.S.A. in Vietnam war for defoliation of forests (*i.e.*, in chemical warfare).

Gibberellins or Gibberellic Acids (GA)

This is very important plant hormone, which was first of all reported in Japan, where a disease in rice called **'Bakanae disease'** or **'Foolish disease'** spread, in which rice plants became abnormally long with significant internodal elongation.

In early part of 20th century, Japanese workers tried to find cause of this disease.

It was first reported by Japanese that there is some connection between bakanae disease and fungus *Gibberella fujikuroi* (*Fusarium moniliformae*).

- Sawada reported that this bakanae disease is caused by a chemical secreted by a fungus *Gibberella fujikuroi* and later it was supported by **Kurosawa. Yabuta and Sumuki** (1938) finally isolated and crystallized this chemical and named it as **Gibberellic acid** or **Gibberellin** (GA_3—first GA known). Nowadays 52 different gibberellins are known, 7 from pea alone.
- They contain essentially **Gibbane** ring in their structure. These are of C–19 or C–20 type and contain **4 isoprene units** and thus 2 terpenes, so these are **diterpenes.**
- The precursor of gibberellins is a 5C-compound, *i.e.*, **isopentenyl pyrophosphate.**

Bioassay of GA

(a) **Dwarf maize leaf sheath elongation bioassay.**

(b) **Barley half seed endosperm test** or **'α-amylase bioassay'.**

Antigibberellins—Cycocel (CCC), **Phosphon-D** and Alar are antigibberellins.

Physiological effects

1. **Seed germination and overcoming dormancy:** GA enhances seed germination by enhancing α-amylase synthesis and thus overcomes dormancy.
   - In photoblastic seeds (*e.g.*, lettuce), seed germination occurs by application of GA even in dark.
2. **Bolting:** Lang (1960) observed certain Rossette plants, in which internodal elongation is very less and bunch of leaves are present at single point. Rossette plants are formed when LDP's are kept under short day conditions.

   When GA is sprayed on these Rossette plants, there is rapid expansion of internodes and flowers with long stalks are produced. This phenomenon is called **bolting**.
3. **Overcoming genetic dwarfism:** Genetic dwarfism is caused by mutation of a single gene. If GA is sprayed on these single gene dwarf plants, genetic dwarfism is overcome and plants become long, *e.g.*, in maize and pea, etc.
4. **Induction of maleness:** On female plant, male flowers are produced by application of GA.
5. **Parthenocarpy:** Gibberellic acids are more potent parthenocarpic agent than auxins.
6. **Root growth:** No effect.
7. **Increase in size of clusters of grapes.**
8. **Etiolation:** When the plants are kept in dark, they become pale yellow in colour and also become abnormally long with considerable internodal elongation, it is called **etiolation.**
   - It is because **'flavanoids'**, which are inhibitors of GA are not formed in dark and hence in absence of flavanoids, GA show their full effect, *i.e.*, elongation (Etiolation).

Cytokinins

During investigations of nutritional requirement of callus tissue culture, **Skoog and Miller** (1954) discovered a substance from old disrupted DNA (obtained from Hering fish sperm), which increased cell division activity in tobacco pith culture. This substance was chemically found to be **6-furfuryl amino purine.**

Later on such substances were also reported from **coconut milk** and **yeast extract** and such substances were named as **cytokinins** because of their property of **inducing cytokinesis** or cell division. These are also called **phytokinins.**

Examples of Cytokinins:

(i) **Zeatin:** Obtained from corn milk by **Letham** (1963).

(ii) **Diphenyl urea.**

Physiological effects

1. **Cell division:** Cell division activity is enhanced by cytokinins (bioassay of cytokinins).
2. **Morphogenesis:** Cytokinins control initiation of plant organs.
   - (a) High cytokinins/auxin ratio—**Differentiation of shoot.**
   - (b) Low cytokinins/auxin ratio—**Differentiation of root.**
   - (c) Intermediate cytokinins/auxin ratio—**Differentiation of both root and shoot.**
   - (d) Intermediate cytokinins/low auxin—**Callus formation.**
3. **Seedling growth:** Application of cytokinins increases seedling growth in width.
4. **Overcoming apical dominance:** Cytokinins overcome apical dominance even in presence of apex.
5. **Induction of femaleness in male plants.**
6. **Retards senescence:** (Richmond-Lang effect).
7. **Retards abscission**
8. **Mobilization of food material:** Is increased by application of cytokinins and this is the reason of release of apical dominance by cytokinins.
9. **Integrity of membranes and retention of chlorophyll.**

Ethylene

Girarden (1864) reported that illuminating gas coming out of mines causes defoliation.

D. Neljubow (1901) reported that illuminating gas coming out of mines causes horizontal growth of seedlings.

Crocker (1930) reported presence of ethylene from plant organs and named it as **gaseous hormone.**

Ranjan and Jha (1940) reported that **black tip of mango** (physiological disease) is caused by gas coming out of brick kiln.

Burg (1962) established that ethylene is the only **gaseous growth regulator.**

- Mol. wt. of ethylene = **28.06**
  and freezing point = **−186°C**
- Ethylene is more synthesized in **nodal regions.** Biosynthesis of ethylene occurs from **methionine** (a sulphur containing amino acid), which serves as a precursor of ethylene in all higher plant tissues.

Physiological effects

1. Seed germination is promoted and hence overcomes dormancy.
2. Induction of femaleness (faminization).
3. Enhances senescence.
4. Enhances abscission.
5. Initiates adventitious root formation but retard the growth of roots.
6. **Triple response:** (Bioassay of ethylene)
   - (a) Growth is checked.
   - (b) Swollen plumule or nodes.
   - (c) Horizontal growth (apogeotropism).

7. **Ethylene and fruit ripening :** In most of the plants, there is a sharp rise in respiration rate near the end of the development of fruit, which sets in progress those changes, which are involved in ripening of fruit. This sharp rise in respiration is called **'Climacteric rise'** or **'Climacteric'** by **Kidd and Went (1930).** Ethylene is responsible for early climacteric.

- The fruits that display or show climacteric are called **Climacteric fruits.** The ripening on demand can be induced in these fruits by exposing them to normal air containing about 1 ppm of ethylene. The ethylene induces the climacteric and ripening soon occurs, *e.g.*, in tomatoes, lemons, oranges, apples, etc. However, all fruits cannot be ripened by exposure to ethylene. Such fruits are called **non-climacteric fruits**, and are insensitive to ethylene, *e.g.*, grapes, never ripe mutants of tomato, etc.
- Ripening fruits release some volatile substance (ethylene), which is responsible for ripening of nearby fruits. So ethylene is a **fruit ripening hormone.**
- Nowadays a liquid called **ethaphon** (2-chloro ethyl phosphonic acid) is being used in fruit ripening as ethaphon continuously release ethylene.
- Suitable combination of gases in atmosphere for fruit ripening is 80% ethylene (C_2H_4) and 20% CO_2.

Abscisic Acid (ABA) (Stress hormone)

Work on ABA started in laboratory of **Dr. Carns (1950)** in U.S.A. on cotton plants.

Carns and Addicott (1961–65) discovered 2 substances from cotton, *i.e.*, **Abscisin-I** from old cotton bolls and **Abscisin II** from young cotton bolls, both of these are capable of inducing abscission of leaves.

Eagles and Wareing (1963) discovered another substance **'Dormin'** from dormant buds of *Acer* (Birch) plants, capable of causing dormancy of seeds.

Later on **Abscisin-I, Abscisin-II** and **Dormin** were found to be **same chemically** and a common name **Abscisic acid** (ABA) was given. Chemically, it is 15-C compound and is having 3 isoprene units (*i.e.*, **sesquiterpene**).

- At 260 λ, it is **dextrorotatory**, whereas at 280 λ, it is **laevorotatory** and this phenomenon is known as **cotton effect.**
- ABA is a naturally occurring **growth inhibitor** in plants.

Physiological effects

1. **Abscission :** ABA is an active substance inducing abscission of different plant parts.

(This is **bioassay** of ABA).

2. **Seed germination :** Seed germination is limited and hence induces dormancy of seeds.

3. **Flowering :** ABA inhibits flowering in long day plants.

- Further maleness induced by GA is reversed by ABA, *i.e.*, ABA induces faminization not alone but in those plants, where maleness was induced by GA.

4. α-amylase synthesis induced by GA is inhibited by ABA.

5. Curvature effect induced by auxins is inhibited by ABA.

6. Cell division and cell elongation is delayed by ABA.

- Thus, ABA counteracts the stimulatory effects of other hormones.

7. **As antitranspirant :** ABA causes partial closure of stomata under drought and thus acts as **antitranspirant** (Hence also known as **Stress hormone**).

- Leaves make large amount of ABA during drought and this ABA functions as messenger that enables plants to conserve water during drought.

8. **Senescence :** ABA induces senescence.

Morphactins

These are a group of artificially synthesized substances, which affect morphology and hence called **Morphactins** (by **Schneider**).

These contain 'fluorene ring' in their structure.

- Generally these are **growth inhibitors.**

Physiological effects

1. **Formation of cornets** (fusion of leaf with stem) and **ochria** (fusion of calyx with other floral parts).
2. Induction of gamopetalous condition.
3. Induction of parthenocarpy.
4. Roof growth and shoot growth is inhibited by morphactines, *i.e.*, leads to shortening of plants.
5. **Depot effect :** First morphactins are accumulated in plants and after sometime show their effect.
6. Seed germination is inhibited.

Wound hormone or Traumatic acid

Haberlandt (1913) reported that injured plants cells release a chemical substance (wound hormone), which stimulate the adjacent cells to divide rapidly in order to heal up the wound. **English** *et. al.* (1939) finally isolated and crystallized this wound hormone and named it as **Traumatic acid.**

PLANT MOVEMENTS

Plants have the capacity of changing their position in response to external (environmental) or internal stimuli, which are known as **plant movements.**

There is a specific region or site where the stimulus is received for changing the position, is called **perception site** or region.

The minimum period for which stimulus should be given for inducing plant movements is called **presentation time**.

Movements are basically of 2 types:

(A) Movements of Locomotion

(B) Movements of Curvature

(A) Movements of locomotion

These are further of 2 types:

1. **Autonomic movements of locomotion :** These are due to internal causes or stimuli.

2. **Induced movements of locomotion or Paratonic movements of locomotion or Tactic movements :** These are due to external stimuli.

1. **Autonomic movements of locomotion :** These are of following types:

(a) **Ciliary movements :** *Volvox, Chlamydomonas* and zoospores of algae and fungi show ciliary movements, *i.e.*, move from one place to another with the help of cilia.

(b) **Amoeboid movements,** *e.g.,* **Slime moulds** (myxomycetes) show locomotion with the help of pseudopodia.

(c) **Cyclosis movements :** Autonomic movements of protoplasm are called cyclosis movements and these are of 2 types:

(i) **Rotation :** Cyclosis around a single central vacuole in clockwise or anticlockwise direction.

○ Rotation movements can be observed in leaf cells of *Hydrilla* and *Vallisneria.*

(ii) **Circulation :** Cyclosis around many vacuoles of a cell in clockwise or anticlockwise directions.

○ Circulation movements ~~can be observed~~ in staminal hair of *Tradescantia* and shoot hair of gourds.

(d) **Excretory movements :** In *Oscillatoria* (blue green alga), apical part shows oscillations due to excretion of some substances called excretory movements.

2. **Induced movements of locomotion or Paratonic movements of locomotion or Tactic movements :** These are of following types:

(a) **Chemotactic movements,** *e.g.,* in **Englemann's experiment,** movements of bacteria towards O_2 concentration.

○ Antherozoids of bryophytes show chemotactic movements towards **sugars** and antherozoids of pteridophytes move towards **malic acid.**

(b) **Phototactic movements,** *e.g.,* many algae move from weak and high light to medium light intensity (*i.e.,* due to light stimulus).

(c) **Thermotactic movements,** *e.g.,* some algae move from cold water to warmer water (*i.e.,* due to temperature stimulus).

(B) Movements of curvature

These are of 2 types:

(I) **Mechanical movements or Hygroscopic movements :** These are shown by **dead organs,** *e.g.,*

Xerochasy, *i.e.,* by loss of H_2O (or on drying), *e.g.,* capsules or pods dehisce due to loss of H_2O.

Hydrochasy, *i.e.,* by absorption of H_2O, *e.g.,* peristomial teeth of moss capsule and elaters of *Equisetum.*

(II) **Vital movements of curvature :** These are shown by living organs. These are of 2 types:

1. **Autonomic movements of curvature :** These are due to internal stimuli, *e.g.,*

(i) Variation in leaves of *Desmodium gyrans* (Indian telegraph plant).

(ii) **Nutation movements :** Shown by **tendrils** which get spirally coiled due to more growth on outerside.

(iii) **Hyponasty,** *i.e.,* more growth on lower surface of leaves, which leads to rolling of leaves.

(iv) **Epinasty,** *i.e.,* more growth or upper surface of leaves, which leads to opening of leaves.

2. **Induced movements of curvature or Paratonic movements of curvature :** These are also called **tropic** and **nastic** movements.

○ Tropic movements are shown by radial, bisymmetrical organs (roots, stem) and in response to **unidirectional external stimulus.** Whereas nastic movements are shown by bifacial organs (leaves, sepals, petals) and are in response to **diffused external stimulus** (not unidirectional).

Tropic movements : These are of following types:

(a) **Phototropic movements :** These are in response to unidirectional light stimulus, *e.g.,* **root** is negatively phototropic and **stem** is positively phototropic.

○ The extreme apices are considered to be positive photoperception sites.

(b) **Geotropic movements :** Due to gravity stimulus, *e.g.,* **primary root** is positively geotropic and **stem** is negatively geotropic.

● Similarly, **stolons, rhizomes** and **secondary roots** move at right angles to gravity and hence **diageotropic.**

● **Coralloid roots of** *cycas* are **ageotropic,** *i.e.,* have no response to gravity.

○ **Cholodny-Went theory** (1926) explains that phototropic and geotropic movements are due to unequal growths caused by unequal distribution of IAA (auxins). The higher concentration of auxin promotes stem growth whereas the same concentration inhibits root growth.

(**Clinostat** is a device used to nullify the effect of gravity).

○ Geotropic stimulus is perceived by **root cap** in case of root and by **stem apex** in case of stem.

(c) **Hydrotropic movements:** Due to water stimulus.

● **Young roots** are positively hydrotropic.

(d) Thigmotropic movements or Haptotropism : Movements shown by tendrils due to contact stimulus.

Nastic movements : These are of following types:

(a) Nyctinastic movements or Sleeping movements : Diurnal movements of leaves and flowers of some plants are nyctinastic movements, *e.g.*, leaves of some legumes show horizontal position during day time and become vertical (sleep) during night. These movements are also shown by leaves of *Oxalis* and flowers of *Tulipa* and *Crocus.*

- Nyctinasty or sleep movement is a nastic response caused by daily rythms of light and dark. *Maranta* **(prayer plant)**, an ornamental house plant provides most common example of nyctinastic response.

(b) Seismonastic movements : These are due to shock or touch stimulus. Such movements are shown by *Mimosa pudica* **(touch me not)**. The leaf of *Mimosa* is compound having four pinna and each pinna is having many pinnules. If a terminal pinnule is touched, the whole leaf droops down. This is due to fact that at the bases of pinnules, pinna and whole leaf, swollen structure called pulvinus is present and drooping is due to loss of turgidity of lower portion of pulvinus.

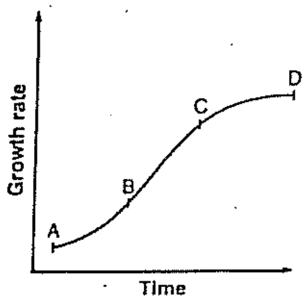
(c) Thigmonastic or Haptonastic movements : Shown by some insectivorous plants like *Dionaea* and *Drosera* due to stimulus of the insects (touch).

MULTIPLE CHOICE QUESTIONS

1. Which of the following is angiospermic saprophyte?
   (a) *Buxbaumia* (b) *Balanophora*
   (c) *Neottia* (d) *Aldovanda*
2. Which is commonly known as 'Indian pipe'?
   (a) *Neottia* (b) *Monotropa*
   (c) *Corallorhiza* (d) *Cephalotus*
3. Which plant is total root parasite? **(BCECE 2002)**
   (a) Mistletoe (b) Broom rape
   (c) *Nepenthes* (d) Dodder
4. Carnivorous plants catch the insects in order to fulfil .... requirement:
   (a) Phosphorus (b) Sulphur
   (c) Nitrogen (d) Hydrogen
5. Which is not an insectivorous plant?
   (a) *Pinguicula* (b) *Dionaea*
   (c) *Moneseis* (d) *Cephalotus*
6. Which is 'Devil's boot' plant?
   (a) *Aldovanda* (b) *Cephalotus*
   (c) *Sarracenia* (d) *Dionaea*
7. Leaf lamina is modified to form a pitcher in:
   (a) *Drosera* (b) *Utricularia*
   (c) *Nepenthes* (d) *Aldovanda*
8. Mycorrhiza is example of:
   (a) Symbiosis (b) Parasitism
   (c) Saprophytism (d) None of these
9. The phenomenon of photoperiodism was put forward by:
   (a) Chailakhyan (b) Butler
   (c) Borthwick (d) Garner and Allard
10. *Xanthium* is an example of:
    (a) LDP (b) SDP
    (c) DNP (d) None of these
11. Critical day length is that photoperiod:
    (a) Below which the flowering occurs
    (b) Above which flowering occurs
    (c) At which flowering occurs
    (d) Above or below which flowering occurs
12. Concept of flowering hormone 'Florigen' was given by:
    (a) Butler (b) Borthwick
    (c) Chailakhyan (d) Allard
13. Which is the receptor of 'photoperiodic stimulus'? **(MPPMT 1999)**
    (a) Stem (b) Shoot apex
    (c) Leaves (d) Roots
14. Which light is most effective in inducing flowering?
    (a) Green (b) Red
    (c) Blue (d) Violet
15. Flowering can be inhibited if dark period is broken by a brief flash of light in:
    (a) LDP (b) SDP
    (c) DNP (d) None of these
16. Term 'Phytochrome' was given by: **(MPPMT 2001)**
    (a) Butler
    (b) Chailakhyan
    (c) Borthwick and Hendricks
    (d) Garner and Allard
17. Phytochrome was first isolated from plasma membrane of:
    (a) Sunflower (b) Corn
    (c) *Mougeotia* alga (d) Spinach
18. Which form of phytochrome is stimulatory to flowering in SDP?
    (a) P_{FR} (b) P_R
    (c) Both (a) and (b) (d) None of these
19. 'Florigen' is chemically made of:
    (a) Auxins (b) Gibberellin
    (c) Auxin and anthesin (d) Gibberellin and anthesin
20. Phytochrome is a pigment:
    (a) Reddish (b) Yellowish
    (c) Bluish (d) Greenish
21. The acceleration of ability to flower by low temperature treatment is called: **(BHU 2000)**
    (a) Chilling (b) Freezing
    (c) Vernalization (d) Photoperiodism
22. The term vernalization was given by:
    (a) Garner (b) Lysenko
    (c) Klippart (d) Melchers
23. The hypothetical flowering hormone called 'Vernalin' produced as a result of low temperature treatment was named by:
    (a) Chailakhyan (b) Melchers
    (c) Butler (d) Borthwick
24. What is the site of vernalization?
    (a) Stem (b) Leaves
    (c) Roots (d) Apical meristem
25. Devernalization is caused at:
    (a) 6°C (b) 7°C
    (c) 30°C and above (d) None of these
26. Most appropriate temperature for vernalization is:
    (a) 0°C (b) 1–6°C
    (c) –6°C (d) 7°C
27. Which is the application of vernalization?
    (a) Crops can be produced earlier
    (b) Increase yield
    (c) Increase cold resistance and resistance to fungal disease
    (d) All of the above
28. Growth is a:
    (a) Qualitative change
    (b) Quantitative change
    (c) Both qualitative and quantitative

(d) None of the above

29. Grand period of growth is represented by:
    (a) L-shaped curve (b) J-shaped curve
    (c) S-shaped curve (d) None of these
30. Growth can be measured by: (CPMT 2002)
    (a) Auxanometer (b) Horizontal microscope
    (c) Crescograph (d) All of these
31. The portion 'BC' of curve represents Log . phase of growth:



    (a) Log phase (b) Lag phase
    (c) Steady phase (d) None of these
32. A phytohormone is:
    (a) Naturally produced (b) Synthetic substances
    (c) Both (a) and (b) (d) None of these
33. Which of the following is a growth inhibitor?
    (a) Auxins (b) Ethylene
    (c) Gibberellic acid (d) Cytokinins
34. The historical experiment on auxins was performed by:
    (a) F.W. Went (b) Jensen
    (c) Darwin (d) Kogl
35. Who first gave the name 'Auxins' to the chemical substances synthesized in the tip?
    (a) Paal (b) Kogl
    (c) F.W. Went (d) Darwin
36. Auxins were first isolated from:
    (a) Corn germ oil (b) *Rhizopus*
    (c) Urine (d) *Avena* tip
37. The another name for 'Heteroauxin' isolated by Kogl from human urine is:
    (a) IBA (b) IAA
    (c) NAA (d) 2,4-D
38. Which is the true natural auxin of higher plants?
    (a) Naphthalene acetic acid (b) Indole butyric acid
    (c) Indole acetic acid (d) 2,4-D
39. Who isolated IAA from *Rhizopus suinus*?
    (a) F.W. Went
    (b) Kogl
    (c) Thimann
    (d) Salkowski and Salkowski
40. Which is the precursor of IAA? (CPMT 1990; EAMCET 2002)
    (a) Acetic acid (b) Tryptophan amino acid
    (c) Glycine amino acid (d) Alanine amino acid
41. Which of the following is a potent root initiator?
    (a) IAA (b) IBA
    (c) NAA (d) None of these
42. Which is responsible for apical dominance? (MPPMT 2000; Kerala PMT 2002)
    (a) GA (b) Cytokinin
    (c) Auxin (IAA) (d) Ethylene
43. Auxins induce:
    (a) Maleness (b) Faminization
    (c) Both (a) and (b) (d) None of these
44. Which is famous 'Weedicide'? (AFMC 2001; BHU 2002)
    (a) IBA (b) NAA
    (c) IAA (d) 2,4-D
45. Which is not correct for auxins?
    (a) Initiate rooting (b) Induce parthenocarpy
    (c) Enhance senescence (d) Retards abscission
46. The cause of 'Bakanae disease' (foolish disease) is:
    (a) Bacteria (b) Algae
    (c) Gibberellins (d) None of these
47. Who first of all isolated and crystallized gibberellic acid?
    (a) Sawada (b) Kurosawa
    (c) Yabuta and Sumuki (d) Jensen
48. α –Amylase test is an important bioassay of :
    (a) Auxins (b) Gibberellins
    (c) Cytokinins (d) ABA
49. Which one is antigibberellin?
    (a) Cycocel (b) Phosphon-D
    (c) Alar (d) All of these
50. Phenomenon of 'Bolting' is caused by which plant hormone?
    (a) Auxins (b) Gibberellins
    (c) Cytokinins (d) Ethylene
51. Femaleness in plants is caused by:
    (a) Auxins (b) Cytokinins
    (c) Ethylene (d) All of these
52. Etiolation phenomenon is related to:
    (a) ABA (b) Cytokinins
    (c) Gibberellic acid (d) None of these
53. Cytokinins were discovered by:
    (a) Girarden (b) Skoog and Miller
    (c) Thimann and Skoog (d) None of these
54. Which is not a cytokinin?
    (a) Diphenyl urea (b) Zeatin
    (c) 6-furfuryl aminopurine (d) Indole propionic acid
55. Cytokinins retard the process of senescence is called:
    (a) Bolting effect (b) Cherry hypothesis
    (c) Cotton effect (d) Richmond Lang effect
56. Which growth hormone causes mobilization of food materials?
    (a) GA (b) Auxins
    (c) Cytokinins (d) Ethylene
57. Which one is gaseous growth regulator? (BHU 2000; Kerala PMT 2002)
    (a) ABA (b) Morphactines

(c) Ethylene (d) Gibberellins

58. 'Triple response' is important bioassay of:
(a) ABA (b) Auxins
(c) GA (d) Ethylene

59. Term 'Climacteric' was given by:
(a) Skoog and Miller (b) Kidd and Went
(c) Thimann and Skoog (d) None of these

60. 'Fruit ripening hormone' is: (CPMT 2001; BCECE 2002)
(a) Auxin (b) Cytokinin
(c) Ethylene (d) ABA

61. Which of the following induces faminization with application of GA_3 and not alone?
(a) Ethylene (b) GA
(c) ABA (d) Morphactines

62. 'Fluorene ring' is feature of:
(a) GA (b) Ethylene
(c) Morphactines (d) None of these

63. Cornets and ochria are formed by application of:
(a) Auxins (b) GA
(c) Cytokinins (d) Morphactines

64. Injured cells release a wound hormone (traumatic acid), which causes adjacent cells to divide to heal up the wound, was first postulated by:
(a) English (b) Haberlandt
(c) Steward (d) Schneider

65. Paratonic movements of locomotion are called:
(a) Tropic movements (b) Nastic movements
(c) Tactic movements (d) None of these

66. The protoplasmic movement called 'Rotation' can be observed in:
(a) Staminal hair of *Tradescantia*
(b) Shoot hairs of gourds
(c) Leaf cell of *Hydrilla*
(d) None of the above

67. Excretory movements of locomotion are observed in :
(a) *Hydrilla* (b) *Tradescantia*
(c) *Oscillatoria* (d) All of these

68. Hygroscopic movements (hydrochasy and xerochasy) occur in:
(a) Living organs (b) Dead organs
(c) Both (a) and (b) (d) None of these

69. The induced (paratonic) movements of curvature, which are directive and occur in bisymmetrical organs are called:
(a) Tactic (b) Tropic
(c) Nastic (d) None of these

70. Which one is diageotropic organ?
(a) Primary Root (b) Stem
(c) Rhizome (d) None of these

71. Which instrument is used to nullify the effect of gravity?
(a) Auxanometer (b) Clinostat
(c) Crescograph (d) Potometer

72. *Mimosa pudica* (touch me not) shows which movements? **(MPPMT 2000; BCECE 2002)**
(a) Haptonastic (b) Seismonastic
(c) Thigmotropic (d) Nyctinastic

73. Nutation is shown by:
(a) Root (b) Stem
(c) Tendril (d) None of these

74. Which of the following is ageotropic?
(a) Primary root (b) Secondary root
(c) Stolons (d) Coralloid roots of *Cycas*

75. Pollen tube shows:
(a) Chemotropism (b) Anemotropism
(c) Phototropism (d) None of these

76. Opening and closing of flowers represent a kind of:
(a) Nutation (b) Mutation
(c) Nastic movement (d) Tropic movement

77. *Desmodium gyrans* exhibits:
(a) Autonomic movements (b) Paratonic movements
(c) Both (a) and (b) (d) None of these

78. Sleeping movement of leguminous plants are:
(a) Nastic movements (b) Growth movements
(c) Tropic movements (d) Turgor movements

79. Optimum temperature for growth generally is:
(a) 0–10°C (b) 10–20°C
(c) 20–25°C (d) 25–30°C

80. A natural growth regulator is :
(a) Ethylene (b) NAA
(c) 2,4-D (d) Benzaldehyde

81. *Chrysanthemum* flowers in winter because:
(a) They are short day plants
(b) They love cool nights of winter
(c) They are long day plants
(d) They hate warm nights of summer

***82.** Hormone involved in phototropism is:
(a) IAA (b) GA_3
(c) Kinetin (d) 2,4-D

83. Flowering in a short day plant is promoted by:
(a) Auxin (b) Gibberellins
(c) Ethylene (d) Cytokinins

84. Dormancy is due to:
(a) Gibberellins (b) Cytokinins
(c) Ethylene (d) ABA

85. The sigmoid curve was proposed by: **(AIIMS 1992)**
(a) Arnon (b) Blackman
(c) Krebs (d) Robertson

86. A high concentration of synthetic auxins is generally used for:
(a) Control of cell enlargement
(b) Weed control
(c) Preventing the growth of lateral buds
(d) Enhancing root inhibition

87. Distribution of growth in a root by marking it at equal intervals with India ink was originally studied by:
(a) Strasburger (b) Sachs
(c) Nitsch (d) Went

88. Auxins are helpful in:
(a) Flower initiation
(b) Prevention of abscission layer
(c) Parthenocarpy and weed eradication
(d) All of the above

***89.** Auxins inhibit the growth of:

(a) Apical buds
(b) Lateral axillary buds
(c) Roots or stem cuttings
(d) Parthenocarpic development of fruits

90. Which is responsible for differentiation of shoot?
(a) High cytokinin/auxin ratio
(b) Low cytokinin/auxin ratio
(c) Intermediate cytokinin/low auxin ratio
(d) None of the above

91. Insectivorous plants are usually adapted to: (BHU 1994)
(a) Water rich soils
(b) Soils deficient in sugars
(c) Soils rich in trace elements
(d) Soils deficient in nitrogenous compounds

92. *Balanophora* is a:
(a) Partial root parasite (b) Partial stem parasite
(c) Total root parasite (d) Total stem parasite

93. Epiphytes are the plants which are dependent on other plants: (CPMT 1990)
(a) Only for water (b) For water and food
(c) Only for food (d) Only for shelter (support)

94. Which of the following is a rootless aquatic herb where a portion of the leaf forms a small bladder that traps water insects?
(a) *Drosera* (b) *Dionaea*
(c) *Utricularia* (d) *Nepenthes*

95. Insectivorous plants:
(a) Are heterotrophic
(b) Cannot manufacture their own protein
(c) Only get supplementary protein food
(d) Cannot manufacture their food other than carbohydrates

96. In *Drosera*, an insectivorous plant, the insect catching mechanism is:
(a) Valvular arrangement in the bladder
(b) Secretion of glandular hairs on the leaves
(c) Pitcher covered with lid
(d) Secretion of glandular hairs in the pitcher

97. Obligate saprophytes are plants which can live:
(a) On living hosts as well as dead material
(b) On living hosts only
(c) Only on dead and decaying organic matter
(d) On dead material as well as living hosts

98. *Dionaea muscipula* is commonly known as:
(a) Butterwort (b) Venus fly trap
(c) Water fly trap (d) Bladderwort

99. The *Orobanche* plant is: (CPMT 1990)
(a) Partial parasite (b) Total root parasite
(c) Symbiont (d) Total stem parasite

100. The insectivorous plant has a rossette of prostrate leaves with winged petioles, the lamina consists of two rounded halves having teeth like margins devised for catching prey, it is: (CPMT 1992)
(a) *Dionaea* (b) *Drosera*
(c) *Nepenthes* (d) *Utricularia*

101. Which of the following is the most common limiting factor for nutrition in soil? (BHU 1990)
(a) Soil reaction or pH (b) Availability
(c) Temperature (d) Tillage

102. Which of the following is a total root parasite?
(a) *Loranthus* (b) *Rafflesia*
(c) *Viscum* (d) *Cuscuta*

103. Which of the following is a heterotroph?
(a) *Opuntia* (b) *Drosera*
(c) *Vallisneria* (d) *Pistia*

104. *Cuscuta* species are:
(a) Partial stem parasites (b) Root parasites
(c) Total stem parasites (d) Epiphytes

105. Which of the following is total root parasite? (CPMT 1992)
(a) *Cuscuta* (b) *Orobanche*
(c) *Loranthus* (d) None of these

106. The example of a saprophyte is:
(a) *Nepenthes* (b) *Utricularia*
(c) *Dionaea* (d) *Monotropa*

*107. The names of many organisms are associated with classical studies in some areas of biology. Which of the following does not show such matching?
(a) Pea-laws of heredity
(b) *Acetabularia*-relationship between nucleus and cytoplasm
(c) *E. coli*—genetic engineering
(d) Barley seeds—role of phytochrome.

108. *Rafflesia arnoldi* is a total parasite on the root of: (Raj. PMT 1991)
(a) *Avena sativa* (b) *Cissus*
(c) *Carica papaya* (d) Parasite

109. Dendrophthoe or *Viscum* is a: (Raj. PMT 1991)
(a) Partial stem parasite (b) Total root parasite
(c) Total stem parasite (d) Partial root parasite

110. Which of the following is a partial root parasite?
(a) *Orobanche* (b) *Viscum*
(c) *Santalum* (d) *Loranthus*

111. A plant inside another plant of different species living symbiotically is said to be: (AFMC 1994)
(a) A parasite (b) Saprophyte
(c) A semi-parasite (d) An endophyte

112. The Dodder (*Cuscuta*) is a: (MDAT Bihar 1990)
(a) Total stem parasite (b) Total root parasite
(c) Partial stem parasite (d) Partial root parasite

113. The insects captured by the insectivorous plants partially fulfil their requirement of: (CPMT 1991)
(a) Enzymes (b) Oxygen
(c) Nitrogen (d) Water

114. Storage sprouting of potato can be prevented by:
(a) IAA (b) Maleic hydrazide
(c) Cytokinins (d) Gibberellins

115. Which one of the following growth regulators is a component of serine and tyrosine t-RNA? (AIIMS 1991)

(a) Cytokinin (b) Auxin
(c) Ethylene (d) Gibberellins

116. An example of a parasitic plant that is also strictly epiphytic is:
(a) *Cuscuta* (Dodder) (b) *Viscum* (Mistletoe)
(c) *Rafflesia* (d) *Orobanche*

117. Which of the following phenomenon is exhibited by *Loranthus* and *Orobanche*? **(Raj. PMT 1991)**
(a) Parasitism (b) Epiphytism
(c) Commensalism (d) Insectivory

118. Which of the following is an insectivorous plant? **(CPMT 1990)**
(a) *Cuscuta* (b) *Orobanche*
(c) *Drosera* (d) *Rafflesia*

119. Which of the following is an example of insectivorous plants?
(a) *Brassica* (b) *Cuscuta*
(c) *Mucor* (d) *Nepenthes*

120. Plants such as 'Sundew' and 'Pitcher plant' are termed:
(a) Carnivorous (b) Parasitic
(c) Symbiotic (d) Autotrophic

121. Which of the following is a physiological movement?
(a) Movement of fern annulus
(b) Movement of moss peristome
(c) Imbibitional movement of seeds
(d) Streaming movement of cytoplasm

122. Plants bend towards the light because:
(a) They need light for photosynthesis
(b) They need light for respiration
(c) Light attracts them
(d) Cells on the shaded side elongate more

123. In phototropic movements curvature takes place:
(a) Far behind the tip (b) At the tip
(c) Behind the tip (d) None of these

124. The classical experiments on phototropism were performed by:
(a) Darwin and Lamarck
(b) Lamarck and Boysen-Jensen
(c) Boysen-Jensen and Darwin
(d) de Vries and Paal

125. The movements of hairs in *Drosera* is:
(a) Thermonastic (b) Thigmonastic
(c) Seismonastic (d) Photonastic

126. With which of the process the Cholodny-Went theory is concerned? **(MPPMT 1990)**
(a) Photorespiration (b) Photomorphogenesis
(c) Phototropism (d) Photoperiodism

127. If the stem goes towards sunlight and root goes just opposite to it then stem movement is called:
(a) Phototropic movement
(b) Positive phototropic movement
(c) Negative phototropic movement
(d) None of the above

128. Geotropism stands for: **(Raj. PMT 1991)**
(a) Attraction due to soil
(b) Attraction due to soil water
(c) Attraction due to gravity
(d) Attraction due to mineral nutrients

129. Who first demonstrated that geotropism was also due to the asymmetric distribution of auxin?
(a) Darwin (b) Went
(c) Dolk (d) Paal

130. The instrument "Clinostat" is used to:
(a) Demonstrate growth (b) Record growth
(c) Record movements (d) Neutralize gravity

131. Greater growth on the lower surface of a bilateral leaf is: **(Raj. PMT 1992)**
(a) Epinasty (b) Hyponasty
(c) Nyctinasty (d) Photonasty

132. Movement of hairs in *Dionaea* and *Drosera* is:
(a) Epinasty (b) Seismonastic
(c) Thigmonastic (d) Thermonastic

133. The closure of lid of pitcher in pitcher plant is: **(CBSE 1995)**
(a) A paratonic movement
(b) A tropic movement
(c) A turgor movement
(d) An autonomous movement

134. Opening of a flower and drooping of a bud are examples of: **(CPMT 1991)**
(a) Movement of curvature (b) Epinastic movement
(c) Hyponastic movement (d) Spontaneous movement

135. The leaves of *Mimosa pudica* drop down when touched due to: **(CPMT 1991)**
(a) Thigmotropism (b) Seismonasty
(c) Nyctinasty (d) Chemonasty

136. If the tip of a seedling is cut off, growth as well as bending ceases because it hampers:
(a) Perception of light stimulus
(b) Transpiration
(c) Respiration
(d) Photosynthesis

137. During the seismonastic movements in *Mimosa pudica* turgor changes occur in:
(a) Leaflets (b) Stipules
(c) Pulvinus (d) Petiole and stem

138. The response of plants to light was first of all discovered by:
(a) Lamarck (b) Darwin
(c) Thimann (d) Went

139. Endogenous rhythmic changes that occur is an organism with a periodicity of twenty four hours is known as:
(a) Diurnal rhythm (b) Circardian rhythm
(c) Both (a) and (b) (d) None of these

140. Movement in the leaf of the touch me-not (*Mimosa*) plant is:
(a) Photonasty (b) Seismonasty
(c) Nyctinasty (d) Epinasty

141. A movement on which only the stimulated organ of an organism exhibit movement whereas the organism itself is stationary is called:

(a) Tropic
(b) Tactic
(c) Nastic
(d) Nutation

142. Gibberellin or gibberellic acid has been successfully employed to induce flowering: (AMU 1991; MPPMT 1992; AFMC 1997)
(a) In short day plants under long day conditions
(b) In long day plants under short day conditions
(c) For some plants
(d) None of the above

143. The leaves of *Mimosa pudica* plant droops down on touch because:
(a) The leaf tissues are injured
(b) The turgor pressure of the leaf base changes
(c) The plant has nervous system
(d) The leaves are very tender

144. Leaves of many grasses are capable of folding and unfolding because they:
(a) Have specialized bulliform cells
(b) Have parallel vascular bundles
(c) Are very thin
(d) Are isobilateral

145. The curvature of coleoptile towards the source of light is due to: (MPPMT 1990)
(a) Enlargement of cells on the illuminated side
(b) Enlargement of cells on the shaded side
(c) Enlargement of cells on both sides
(d) No enlargement

146. Leaves of flowering plants are known to carry on all of the following except:
(a) Vegetative propagation
(b) Transpiration
(c) Photosynthesis
(d) Nerve-impulse conduction

147. Tertiary roots are:
(a) Plageotropic
(b) Ageotropic
(c) Positive geotropic
(d) Negative geotropic

148. Generally the plants grow towards water and this phenomenon is known as:
(a) Hydrotropism
(b) Phototropism
(c) Thigmotropism
(d) Geotropism

149. The effect of unilateral light may be neutralised by placing potted plant on a clinostat in:
(a) Horizontal direction
(b) Horizontal direction and rotating it
(c) Vertical direction
(d) Vertical direction and rotating it

150. Movement of a plant organ at right angle to the influence of gravity is called: (Raj. PMT 1991)
(a) Phototropism
(b) Photonastism
(c) Plageotropism
(d) Diageotropism

151. A clinostat is associated with:
(a) Turgor movements
(b) Measurement of leaf area
(c) Thigmotropism
(d) Geotropism

152. Clinostat is useful in studies dealing with: (MPPMT 1990)
(a) Heliotropism
(b) Geotropism
(c) Phototropism
(d) Chemotropism

153. Geotropism movements are induced as a result of:
(a) Bringing down of auxin content on the lower side of the stem
(b) Bringing down of the auxin content in the stem apex
(c) Bringing down of the auxin content in the root apex
(d) None of the above

154. Closure of leaflets or the movements in leaves of *Mimosa pudica* is:
(a) Seismonastic or turgor movement
(b) Photonastic movement
(c) Thigmotactic movement
(d) Nyctinastic movement

155. Phototropic curvature is promoted by:
(a) Red light
(b) Violet light
(c) Blue light
(d) Green light

156. Periodical liberation of gametes in many brown algae and daily movements of the leaves of leguminous plants is an example of:
(a) Exogenous rhythms
(b) Lunar rhythms
(c) Circadian rhythms
(d) Phototropism

157. What type of diurnal movements occur in stomata? Or the day opening and night closing movement in *Portulaca* flower is:
(a) Photonasty
(b) Nyctinasty
(c) Phototaxis
(d) Phototropism

158. Continuous movement of protoplasm in *Hydrilla* leaves in an example of:
(a) Spontaneous movement
(b) Induced movement
(c) Paratonic movement
(d) Tropic movement

*159. Best material for demonstration of streaming movements of protoplasm within living cells is:
(a) Onion peelings
(b) Staminal hairs of *Tradescantia*
(c) Sensitive plant
(d) Pith cells

160. Phototropic and geotropic movements in plants have been traced to be linked with: (CBSE 1990)
(a) Enzymes
(b) Starch
(c) Gibberellins
(d) Auxins

161. Twining of tendrils around a support is a good example of: (CBSE 1995)
(a) Chemotropism
(b) Nastic movements
(c) Phototropism
(d) Thigmotropism

162. Response of plants in turning towards a source of light is:
(a) Tropism
(b) Climatic response
(c) Habit
(d) All of these

163. Which of the following movements in plants is not related to changes in auxin levels? (CBSE 1990)
(a) Nyctinastic leaf movements
(b) Movement of roots towards soil
(c) Movement of sunflower tracking the direction of sun

(d) Movement of shoot towards light

164. The coiling of a tendril around a support on getting the touch stimulus is called:
(a) Chemotropism (b) Thigmotropism
(c) Seismonasty (d) Hydrotropism

165. Roots are positively geotropic:
(a) Always (b) Mostly
(c) Rarely (d) Never

166. Tropism is a movement which is exhibited by:
(a) Motile cells only
(b) Sudden change in turgor pressure
(c) Some internal stimulus
(d) Unequal growth of opposite sides of an organ

167. The movement of plant organs in response to the force of gravity is called:
(a) Hydrotropism (b) Geotropism
(c) Heliotropism (d) Phototropism

168. Thigmotropism is the response of the plant to:
(a) Water (b) Gravity
(c) Contact (d) Light

169. A plant bends towards the source of light when exposed to the light on only one side. Which of the following is the best explanation of the phenomenon?
(a) They need light for photosynthesis
(b) The apices of their stems are attracted by light
(c) Some auxin accumulates on the shaded side to induce greater cell elongation on that side
(d) Light stimulates the cells on the illuminated side to increase in length

170. The movement of pollen tube from stigma to micropyle is: **(CPMT 1994)**
(a) Thigmotropic (b) Geotropic
(c) Chemotropic (d) Hydrotropic

171. When tendrils of a stem climbs about a solid object, it is known as: **(CBSE 1991)**
(a) Phototropism (b) Thigmotropism
(c) Geotropism (d) Chemotropism

172. Twining of a pea tendril around a support is a good example of: **(CPMT 1993)**
(a) Thigmotropism (b) Nastic movement
(c) Chemotropism (d) Phototropism

*173. The hormone which was discovered through "Foolish seedling disease" of rice is: **(AIIMS 1992)**
(a) Indole 3-acetic acid (b) Ethylene
(c) Gibberellin (d) Kinetin

174. An apparatus commonly used to demonstrate phototropism is:
(a) Arc auxanometer (b) Heliotropic chamber
(c) Potometer (d) Clinostat

175. Opening and closing of flowers represent a kind of:
(a) Autonomic movement (b) Nutation
(c) Tropic movement (d) Nastic movement

176. When mature green bananas are put in a sealed plastic bag they remain green for many days. However, if they are sealed with a ripe orange, the bananas turn yellow within a few days. The reason is:
(a) Orange produces ethylene which induces fruit ripening
(b) Orange removes CO_2 which inhibits fruit ripening
(c) Orange removes O_2 released from green bananas
(d) Orange produces CO_2 which activates fruit ripening

*177. Attraction of antherozoids towards the archegonium under the influence of chemicals is termed as: **(CPMT 1992)**
(a) Chemotaxis (b) Chemotropism
(c) Hydrotropism (d) Phototropism

178. Important factors that modify geotropic response in plants are:
(a) Root and shoot apices, humidity, temperature and light
(b) Root and shoot apices, temperature, light and CO_2 content of air
(c) Phytochrome, protein content of leaves, humidity and temperature
(d) None of the above

179. Protoplasmic streaming movements are referred as:
(a) Movement of curvature
(b) Movement of locomotion (spontaneous or autonomic)
(c) Thigmonastic
(d) Photonastic

180. Nastic movement is not caused by:
(a) Light (b) Temperature
(c) Chemical (d) Sugar

181. Movements due to light are shown by:
(a) Flowering plants (b) Lower plants
(c) All land plants (d) All the plants

182. Movement in which the whole organism or the organelle of a cell exhibits movement under the influence of a stimulus is termed:
(a) Tropic movement (b) Tactic movement
(c) Nastic movement (d) Nutritional movement

183. Daily movements of leaves is an example of:
(a) Lunar rhythm (b) Circardian rhythm
(c) Ultradian rhythm (d) Phototropism

184. A green plant bends towards a light source when exposed from one side, because:
(a) Stem apices are attracted by light
(b) Apices need light for photosynthesis
(c) Auxin accumulates on the shaded side
(d) Light induces growth

185. The plants bend towards the source of light on account of the movement of curvature known as:
(a) Geotropism (b) Thigmotropism
(c) Chemotropism (d) Phototropism

*186. Sleep movements of leaves in certain plants are due to:
(a) Decrease in intensity of light
(b) Differential growth at the base of leaf
(c) Excess of transpiration
(d) The leaves getting tired of carrying on photosynthesis

187. What type of movement is characteristic of *Riccia* and fern antherozoids? **(Raj. PMT 1992)**

(a) Chemotactic (b) Chemotropic
(c) Phototactic (d) Thigmotactic

188. How long a plant organ be kept under the influence of gravity in order to exhibit a geotropic response?
(a) Few seconds (b) Few minutes
(c) Few hours (d) At least for a week

189. Movement exhibited by telegraphic plant (*Desmodium gyrans*) comes under: **(CPMT 1991)**
(a) Hydrotropic movement
(b) Geotropic movement
(c) Negative geotropic movement
(d) None of the above

190. A plant is kept on the window, it bends towards the outside because of:
(a) More elongation of cells of the shaded portion
(b) Apical dominance
(c) Osmotic pressure
(d) Photosynthesis

191. Bending of a plant organ towards the light is: **(AFMC 1990)**
(a) Tropism (b) Trophic response
(c) Turgor movement (d) Taxism

192. Phototropism in shoots is attributed to:
(a) Abscisic acid (b) Cytokinins
(c) Auxins (d) Gibberellins

193. Horizontally placed stem exhibits apogeotropism due to:
(a) The accumulation of auxin on the upper side
(b) The accumulation of auxin on the lower side
(c) Cell enlargement of the upper side
(d) Cell shrinkage on the lower side

194. Nyctinasty and thigmonasty movements are seen in:
(a) *Mimosa* (b) *Drosera*
(c) *Cuscuta* (d) *Utricularia*

195. Which one of the following is the motivative force for growth?
(a) Turgor pressure (b) Root pressure
(c) Atmospheric pressure (d) Osmotic pressure

196. Fruit ripening can be accelerated by application of:
(a) Auxins (b) Cytokinins
(c) Gibberellins (d) Abscisic acid

197. The growth of an organism follows:
(a) J-shaped curve (b) Hyperbolic curve
(c) Sigmoidal curve (d) Parabolic curve

198. Phytochrome is found in:
(a) Algae (b) Fungi
(c) Gymnosperms (d) Angiosperms

199. What is the cause of excurrent habit in *Pinus*?
(a) High concentration of ABA.
(b) High concentration of cytokinin
(c) Presence of gibberellin
(d) Presence of apical dominance

200. Seedless tomatoes are produced by:
(a) Growing tomato plants is mineral soln.
(b) Supplying radioactive compounds
(c) Spraying hormones on flowers
(d) Propagating tomato plants from cuttings

201. The natural plant hormones were first isolated from:
(a) Cotton fruits, spinach leaves and rice plants
(b) *Avena* coleoptiles, spinach leaves and fungus *Gibberella*
(c) Corn germ oil and human urine
(d) Human urine and rice plant

202. In which of the following three phases an organism exhibits rapid growth?
(a) Lag phase (b) Log phase
(c) Stationary phase (d) All of these

203. An apple tree can be made to produce large fruits than usual by:
(a) Applying hormones
(b) Thinning of blossoms
(c) Decapitating the stem apex
(d) Defoliating

204. The growth involves:
(a) Cell division (b) Cell enlargement
(c) Cell maturation (d) All of these

205. Which of the following instrument can be used to record plant growth by seconds (*i.e.*, in fraction of a minute)? **(Raj. PMT 1991)**
(a) Arc auxanometer (b) Arc indicator
(c) Space marker disc (d) Crescograph

*206. Which of the following plants material is widely used in the preparation of culture medium?
(a) *Pinus longifolia* (b) *Cocos nucifera*
(c) *Borassus flabellifer* (d) *Cycas revoluta*

207. The classical experiments on growth were performed by:
(a) Lamarck and Boysen-Jensen
(b) Boysen-Jensen and Darwin
(c) Darwin and Lamarck
(d) de Vries and Paal

208. Whose technique is employed for the extraction and elimination of hormones?
(a) Beck - (b) Beer
(c) Garner (d) Allard

209. In plants growth is:
(a) Restricted to certain regions or structures
(b) Irreversible
(c) Changed in size
(d) All of the above

210. Maximum growth is in: **(CPMT 1993)**
(a) Exponential phase (b) Lag phase
(c) Stationary phase (d) Decline phase

211. Apical dominance in higher plants is due to: **(Re. Ex. CPMT 1991)**
(a) Photoperiodism (b) Enzymes
(c) Hormones (d) Light demand

212. In a growing plant, the very first phase during the process of growth is:
(a) Cell division (b) Cell enlargement
(c) Cell differentiation (d) Cell maturation

213. Which of the following substance acts as a key growth regulator?
(a) ATP and food (b) Hormones
(c) Enzymes (d) Auxin and vitamins

214. One of the following is a precursor of auxin:
(a) Phenylalanine (b) Methionine
(c) Tryptophan (d) Cytosine

215. Auxin-B was first isolated by:
(a) Kogl and Erxlaben
(b) Kogl, Erxlaben and Hagen-Smith
(c) Miller and Skoog
(d) Yabuta and Sumuki

216. Which of the following stimulates the plant for growth?
(a) Cytokinin (b) Ethylene
(c) Auxin (d) Gibberellin

217. Which growth hormone is responsible for apical dominance?
(a) Auxin (b) Cytokinin
(c) Gibberellin (d) Ethylene

218. Rooting hormone is: **(Raj. PMT 1990)**
(a) Auxin (b) Gibberellin
(c) Cytokinin (d) Synthetic auxin and IAA

219. Bonsi nature of plant is maintained by drastic pruning which causes the deficiency of: **(CBSE 1990)**
(a) Auxin (b) Gibberellins
(c) Cytokinins (d) Minerals

220. A substance which accelerates the growth in stem is:
(a) Etiolin (b) Auxin
(c) Vitamin (d) Enzyme

221. The principal and naturally occurring auxin in higher plants is:
(a) NAA (b) MH (Maleic hydrazide)
(c) IAA (Indole acetic acid) (d) 2,4-D

222. Substances which originate at the tip of stem and root and control the growth of distant organs are:
(a) Enzymes (b) Hormones
(c) Vitamins (d) Food substances

223. Which of the following hormone is concerned chiefly with root initiation? **(BHU 1991)**
(a) IBA (b) GA_3
(c) ABA (d) Kinetin

224. During cell enlargement phase of growth, molecules of new cell wall material are inserted between the original molecules of stretched wall. This process is known as:
(a) Intussusception (b) Apposition
(c) Integration (d) None of these

225. Evergreen trees remain green throughout the year on account of:
(a) Cold climate
(b) Absence of leaf fall
(c) Leaves falling in small number at intervals
(d) Supply of moisture throughout the year

226. Enzymes, vitamins and hormones can be classified into a single category of biological chemicals because all of them:
(a) Active in regulating metabolism
(b) Are proteins
(c) Are synthesized within the body
(d) Enhance the oxidative metabolism

*227. Maximum amount of growth in root occurs:
(a) In the presence of light (b) At its apex
(c) Behind the apex (d) In the presence of soil

228. Which of the following hormone is translocated to other parts of the plants and exhibits a polar movement?
(a) Auxin (b) GA_3
(c) Zeatin (d) ABA

229. Plant hormone which is translocated to other parts for growth of the plant is known as:
(a) Gibberellin (b) Cytokinin
(c) Indole acetic acid (d) None of these

230. Which one of the following plant functions is not generally governed or controlled by auxin?
(a) Apical dominance (b) Phototropism
(c) Photosynthesis (d) Growth

231. High concentration of synthetic auxin 2,4-D is used as a:
(a) Vitamin (b) Fertilizer
(c) Insecticide (d) Weedicide

232. High concentration of synthetic auxins would:
(a) Prevent lateral buds to grow
(b) Kill weeds
(c) Cause root initiation
(d) Control cell enlargement

233. Auxins are:
(a) Growth catalysts (b) Destroyers of growth
(c) Growth hormones (d) Inhibitors of growth

234. Such substances which are produced at apex of stem and affect growth in other parts of plant, come under category:
(a) Hormones (b) Vitamins
(c) Enzymes (d) Proteins

235. Which of the following effects of auxins on plants is the basis for commercial application?
(a) Callus formation
(b) Curvature of stem
(c) Induction of root formation in stem cuttings
(d) All of the above

236. Seed dormancy is regulated by:
(a) Ethylene (b) ABA
(c) IAA (d) GA_3

237. If a leaf segment of *Bryophyllum* plant is in soil, it produces new plants. This is because its leaf has:
(a) Small embryos
(b) Buds
(c) High concentration of auxin and cytokinins
(d) High concentration of cytokinins

238. What emerges first at the time of seed germination?
(a) Radicle/root (b) Plumule/shoot
(c) Cotyledons (d) Hypocotyl

239. Pruning makes the hedge plant dense because:

(a) Pruning removes shade and allow germination of new seedling to impart a dense growth
(b) Injury induces dense growth
(c) Apical dominance is removed
(d) Roots sprout additional branches

240. Plants differ from animals in having:
(a) Localised growth
(b) Localised growth and indefinite life span
(c) Indefinite life span
(d) Definite life span

241. Auxins are abundantly produced in:
(a) Root
(b) Meristimatic region of the root
(c) Shoot
(d) Meristematic region of the shoot

242. Supra-optimal concentration of auxins:
(a) Promotes flowering
(b) Kills the plant
(c) Prevents shortening of the internodes
(d) Promotes growth in both stem and root apex

243. Auxanometer is an instrument with which we can measure the:
(a) Rate of respiration (b) Rate of photosynthesis
(c) Rate of growth (d) Rate of transpiration

*244. Which of the following technique is employed for the separation and identification of phytohormones?
(a) Polarizing microscopy (b) Auto-radiography
(c) Gas chromatography (d) Cell fractionation

245. A good crop of tea leaves from a single plant can be obtained by: **(MPPMT 1990)**
(a) Removing the apical buds of the main shoot and the branches
(b) Cutting off the top of the plant and them applying auxin to the cut ends
(c) Supplying auxin from the tip of the plant as well as through roots
(d) Feeding auxin to the plant through roots

246. High concentration of hormone will:
(a) Kill the plant
(b) Cause chlorosis in leaves
(c) Cause stunting in plants
(d) Show no effect on the plant

247. Cell wall extension and cell elongation is controlled by: **(Raj. PMT 1990)**
(a) Auxin (b) Gibberellin
(c) Cytokinin (d) Ethylene/ABA

248. In tissue culture, differentiation of root and shoot can be controlled by: **(CPMT 1993)**
(a) Change in light intensity
(b) Giving temperature shocks
(c) Using tissue of right size
(d) Modifying auxin and cytokinin ratios in the medium

249. Cytokinin was first of all separated from:
(a) *Nicotiana* (b) *Cocos*
(c) Sperms of Herring fish (d) *Zea mays*

250. Exogenous application of gibberellins induces male flowers formation on genetically female plants in:
(a) *Cucumis* (b) *Cucurbita*
(c) *Carica* (d) *Coccinia*

251. The biological activity of IAA is tested by: **(CPMT 1990)**
(a) α-amylase test (b) *Avena* curvature test
(c) Soybean callus test (d) *Xanthium* leaf disc test

252. Apical dominance is due to: **(CBSE 1992)**
(a) Gibberellin in the lateral buds
(b) Cytokinins in the leaf tip
(c) Auxin in the shoot tip
(d) Abscisic acid in lateral bud

253. At the onset of seed germination the digestive enzymes/amylase are produced by the action of: **(AMU 1992)**
(a) Auxins (b) Gibberellins
(c) Cytokinins (d) Ethylene

*254. A dwarf pea plant was treated with GA, it grew as the pure tall plant. If this treated plant was crossed with a pure tall plant the phenotypic ratio of the F_2 is likely to be:
(a) All tall (b) 50% tall, 50% dwarf
(c) 75% tall, 25% dwarf (d) All dwarf

255. The following is a naturally occurring growth inhibitor:
(a) NAA (b) GA_3
(c) ABA (d) IAA

256. GA was discovered by:
(a) Yabuta and Sumuki
(b) Utrocheat and Dolk
(c) Donoho and Walker
(d) Hoshimata and Rappaport

257. Elongation of genetically dwarf plants can be caused by:
(a) Auxin (b) Gibberellin
(c) Florigen (d) None of these

258. Gibberellin was first isolated from: **(Raj. PMT 1991)**
(a) Ascomycetous fungus (b) Rice roots
(c) Oat coleoptile (d) Coconut milk

259. Specific property attributed to gibberellin is:
(a) Elongation of genetically dwarf plants
(b) Promotion of abscission in fruits
(c) Shortening of genetically tall plants
(d) Rooting of stem cuttings

260. Which hormone prevents the germination of seeds?
(a) Auxin (b) Gibberellin
(c) Cytokinin (d) Dormin

261. Stomata clusure in response to leaf stress is mediated by: **(BHU 1993)**
(a) IAA (b) IBA
(c) ABA (d) 2,4-D

262. Which of the following plant hormone substitutes for long photoperiod in flowering plants? **(CPMT 1990)**
(a) Auxin (b) Gibberellin
(c) Cytokinin (d) Ethylene

263. Bioassay for auxin is:
(a) *Avena* curvature test (b) Green leaf test

(c) Dwarf maize test (d) Cell division test

264. Which one of the following nutrients is concerned with the growth of the plants in view of their role in synthesis of auxin? **(CBSE 1991)**
(a) S (b) Mn
(c) Zn (d) K

265. Gibberellin was isolated from:
(a) An alga (b) A fungus
(c) A bacterium (d) A virus

266. Genetic dwarfness is cured by treatment with: **(CBSE 1992)**
(a) Auxin (b) Gibberellin
(c) Kinetin (d) Abscissin

267. Which of the following is a naturally occurring inhibitor of DNA synthesis and growth?
(a) ABA (b) IAA
(c) NAA (d) GA_3

268. Legume seeds exhibit dormancy because of:
(a) Undeveloped embryo (b) Hard seed coat
(c) Absence of cytokinins (d) Absence of GA_3

269. Which of the following hormones can replace vernalization?
(a) Cytokinins (b) Auxins
(c) Ethylene (d) Gibberellins

270. Which of the following is not true about auxins?
(a) It inhibits lateral growth
(b) It promotes stem elongation
(c) It promotes cell division
(d) It helps hyperelongation

271. Higher concentration of auxin is present in: **(CBSE 1990)**
(a) Root apex (b) Stem apex
(c) Internodes (d) Petiole and leaves

272. Gibberellins differ from auxins since they produce:
(a) Cell division (b) Stem elongation
(c) Root initiation (d) Shortening of internodes

273. Which of the following exhibits a non-polar movement? **(CBSE 1992)**
(a) Gibberellin (b) Auxin and cytokinin
(c) ABA (d) Auxin

274. The red, far-red response is mediated by:
(a) IAA (b) GA
(c) CK (d) ABA

275. Which of the following combination induces shoot differentiation in tobacco callus?
(a) High cytokinin and low auxin
(b) High auxin and low cytokinin
(c) Equal proportion of auxin and cytokinin
(d) Only auxin and no cytokinin

276. Cytokinins have the ability to:
(a) Substitute cold treatment
(b) Cause root formation
(c) Cause morphogenesis
(d) Convert dwarf plants into tall plants

277. Highest proportion of ethylene is found in:
(a) Green apple (b) Ripened banana
(c) Green banana (d) Fresh potato tuber

278. Which of the following is a growth inhibitor?
(a) Ethylene (b) Cytokinin
(c) Auxin (d) Gibberellin

279. Internodel elongation is stimulated by: **(EAMCET 1990)**
(a) Auxin (b) Cytokinin
(c) Gibberellin (d) Phenol

280. Dwarfness of plant can be controlled by treating it with: **(CBSE 1992)**
(a) Gibberellic acid (b) Cytokinin
(c) Antigibberellin (d) Auxin

281. Indole 3-acetic acid, called as auxin was first isolated from: **(CPMT 1990)**
(a) Human urine (b) Corn germ oil
(c) *Fusarium* (d) *Rhizopus*

282. Gibberellin was first extracted from:
(a) *Gelidium* (b) *Aspergillus*
(c) *Gibberella fujikuroi* (d) *Gracillaria*

283. Which of the following is responsible for apical dominance? **(CBSE 1991)**
(a) GA_3 (b) IAA
(c) ABA (d) Florigen

284. GA_3 (Gibberellic acid) induces: **(CPMT 1993)**
(a) Cell division
(b) Seed dormancy
(c) Flowering in short day plants in long day conditions
(d) Flowering in long day plants in short day conditions

285. A natural antigrowth hormone or growth inhibitor is: **(Raj. PMT 1992)**
(a) Abscisic acid (b) Ethylene
(c) Gibberellic acid (d) Kinetin

286. Abscisic acid treatment results is: **(CBSE 1991)**
(a) Leaf expansion (b) Stem elongation
(c) Stomatal closure (d) Root elongation

287. Senescence in plants can be delayed by applying: **(CPMT 1993)**
(a) Auxins (b) Cytokinins
(c) GA (d) Ethylene

288. A natural growth regulator (hormone) is: **(CPMT 1995)**
(a) Benzaldehyde (b) 2,4-D
(c) NAA (d) Ethylene

289. For plant tissue culture among the following which one is required?
(a) Kinetin (b) Coumarin
(c) Truson (d) Caffeine

290. Gaseous hormone is: **(Raj. PMT 1990)**
(a) Ammonia and methane (b) Acetylene
(c) Nitrous oxide (d) Ethylene

291. Abscisic acid controls: **(Raj. PMT 1990)**
(a) Shoot elongation
(b) Cell elongation and cell wall formation
(c) Cell division
(d) Leaf fall and dormancy

292. Auxin inhibits the growth of: **(CPMT 1990)**
(a) Apical buds

(b) Lateral axillary buds

(c) Roots on stem cuttings

(d) Parthenocarpic development of fruits

293. Under adverse environmental conditions plants develop stress hormone which is: (CBSE 1993)

(a) Ethylene (b) Aminopurine

(c) 2,4-D (d) Abscisic acid

294. What is ethylene to a plant?

(a) Ethylene (b) Gaseous hormone

(c) Waste product (d) Respiratory product

295. Which of the following is growth inhibitor? (BHU 1992)

(a) Gibberellic acid (b) Auxin

(c) Cytokinin (d) Ethylene

296. Which of the following is capable of delaying yellowing of leaves?

(a) Gibberellins (b) Cytokinins

(c) ABA (d) Auxins

297. The fruit softens and attains edible maturity due to:

(a) Conversion of starch into sugar

(b) Gel formation at acidic pH

(c) The incorporation of pectate in the middle lamella

(d) Hydrolysis of cell walls

298. Cytokinin:

(a) Refers to cell movements

(b) Causes dormancy

(c) Is a hormone whose main function is the induction of cell division and delay in senescence

(d) Is the process of cell division

299. *Avena* coleoptile test to find out the amount of growth promoting hormones was discovered by: (CPMT 1990)

(a) F.W. Went (b) L.J. Ouds

(c) K.V. Thimann (d) F. Skoog

300. Ripening of banana is accompanied with:

(a) Sudden rise in cytokinin

(b) Sudden rise in auxin

(c) Sudden rise in ethylene

(d) Sudden rise in gibberellin

301. Ethylene is a:

(a) Solid hormone (b) Gaseous enzyme

(c) Gaseous hormone (d) Liquid gas mixture

302. The following hormone is concerned chiefly with cell division in plants:

(a) 2,4-D (b) IAA

(c) GA (d) Kinin (Zeatin)

303. Which one is used for artificial ripening of banana? (CBSE 1992)

(a) Cytokinin (b) Ethylene

(c) Auxin (d) Coumarin

304. Substance of which plants is used in tissue culture?

(a) Tomato (b) Coconut

(c) Tobacco (d) *Colchicum*

305. Cytokinin are known to : (CBSE 1992)

(a) Inhibit cytoplasmic movement

(b) Help in retention of chlorophyll

(c) Influence water movement

(d) Promote abscission layer formation

306. Growth regulator that retards ageing of plant organ is: (CBSE 1993)

(a) Cytokinin (b) Auxin

(c) ABA (d) GA_3

307. Pneumatophores are:

(a) Negatively geotropic (b) Positively geotropic

(c) Negatively phototropic (d) Thigmotropic

308. Sprouting of potato during storage is due to: (CET Chandigarh 1997)

(a) Abscisin (b) Auxin

(c) Cytokinin (d) Gibberellin

309. Elongation of a genetically dwarf plants is possible by application of:

(a) Vitamin (b) Kinetin

(c) Gibberellin (d) X-rays

310. A hypothetical chemical involved in the flowering of plant is:

(a) Indole acetic acid (b) Florigen

(c) Gibberellin (d) Kinetin

311. Which of the following is a long day plant? (Raj. PMT 1991)

(a) Tobacco and potato (b) Sugar cane

(c) Wheat and radish (d) *Chrysanthemum*

312. Which one of the following is not essential for germination of seed?

(a) Water (b) Air

(c) Temperature (d) Light

313. Hormone concerned primarily with cell division is: (BHU 1991; CBSE 1991)

(a) GA_3 (b) IAA

(c) Cytokinin (d) NAA

314. Which of the following is not naturally occurring plant hormone?

(a) IAA (b) GA_2

(c) 2,4-D (d) Gibberellin

315. Herbicides are chemicals which control:

(a) Fungi (b) Weeds

(c) Nematodes (d) Insects

316. The excess amount of CO_2:

(a) Retards growth

(b) Accelerates growth

(c) Affects the growth slowly

(d) Does not affect growth

317. Which of the following plays a prominent role in leaf growth?

(a) Carbonate (b) Nitrate

(c) Sulphate (d) Phosphate

*318. In plants etiolation is caused by the deficiency of:

(a) N (b) Fe

(c) Light (d) Mg

319. Which two factors primarily affect the developmental phase of growth in plants?

(a) Rainfall and temperature

(b) Light and wind

(c) Light and temperature
(d) Temperature and relative humidity

320. Presence of which of the following is associated with the dormancy of seed?
(a) Malic acid (b) Ethylene
(c) NAA (d) Abscisic acid

321. One of the following shows interconversion due to red-far red light:
(a) Chlorophyll (b) Carotenoids
(c) Cytochromes (d) Phytochromes

322. Phytochrome is sensitive to: **(BHU 2001)**
(a) Red light (b) Far red light
(c) Both (a) and (b) (d) Green light

323. Photoperiodism is:
(a) Recurrence of day and night
(b) Effect of day length on plant growth
(c) Effect of day length on flowering
(d) Growth curvature in response of light

324. Photomorphogenetic pigment in plant is:
(a) Chlorophyll (b) Phytochrome
(c) Xantophyll (d) Carotene

325. If soaked pea seeds are kept in four respiratory flasks they would germinate best in flask containing:
(a) Carbon dioxide (b) Oxygen
(c) Water (d) Nitrogen

326. A green plant turns pale when transferred to prolonged darkness, it represents a phenomenon called:
(a) Etiolation (b) Chlorosis
(c) Cytorrhisis (d) Paleolation

327. Phytochrome is involved in:
(a) Photoperiodism (b) Geotropism
(c) Phototropism (d) Photorespiration

328. Name of the growth hormone having specific effect on cell division is: **(CPMT 1992)**
(a) Gibberellin (b) Kinetin
(c) Auxin (d) All of these

***329.** Richmond-Lang effect is shown by: **(MPPMT 1993)**
(a) Auxins (b) Gibberellins
(c) Kinetin (d) Ethylene

330. One of the following causes rooting in cuttings:
(a) IBA (b) 2,4-D
(c) GA_3 (d) ABA

331. Phytohormones are: **(CBSE 1990)**
(a) Hormones regulating growth from seed to adulthood
(b) Hormones regulating secondary growth
(c) Growth regulators synthesized by plants and influencing physiological processes
(d) Hormones regulating flowering

***332.** A plant which needs not less than 10 hours of light to flower should be a:
(a) Long day plant (b) Short day plant
(c) Day neutral plant (d) None of these

333. The short day winter annual 'Pancy' belongs to the genus:
(a) *Viola* (b) *Papaver*
(c) *Iberis* (d) *Malva*

334. Which of the following processes is never affected by light in a vegetable garden?
(a) Seed germination
(b) Flowering
(c) Osmosis and fertilization
(d) Food manufacture

335. Which pigment controls photoperiodism, flowering/seed germination /stem elongation/ stomatal opening/ transpiration and photomorphogenesis?
(a) Anthocyanin (b) Phytochrome
(c) Cytochrome (d) Xanthophyll

336. Pineapple can be made to flower in off season by:
(a) Zeatin (b) Ethylene
(c) Temperature (d) Short days

337. Which of the following are short day plants?
(a) Radish (b) Maize
(c) Soybean (d) Sugar beet
(e) None of the above

338. In the absence of light which one of the following would increase?
(a) Uptake of water (b) Elongation of internodes
(c) Uptake of mineral salts (d) Extension of lamina

339. Phytochrome is used in:
(a) Seed germination only
(b) Transpiration only
(c) Flowering only
(d) All physiological processes exhibited by the plants such as seed germination, flowering, stem elongation and transpiration

340. The effect of daily light period on flowering is called:
(a) Photo-oxidation (b) Phototropism
(c) Photoperiodism (d) Photorespiration

341. The pigment which absorbs red and far-red light is: **(CPMT 1997)**
(a) Phytochrome (b) Xanthophyll
(c) Cytochrome (d) Carotene

342. Tendrils best explain the phenomenon of:
(a) Diageotropism (b) Heliotropism
(c) Thigmotropism (d) Seismonastic

343. Which of the following exerts Richmond and Lang effect, *i.e.*, prevent loss of chlorophyll? **(CBSE 1992)**
(a) Kinetin (b) Auxin
(c) Light (d) Gibberellin

***344.** DCMU is a herbicide which kills the plant by:
(a) Inhibiting photolysis of water as it is a strong inhibitor of pigment system I
(b) Inhibiting carbon dioxide fixation as it is a strong inhibitor of pigment system II
(c) Checking respiration
(d) Destroying chloroplast

345. Effect of length of the day (light duration) on flowering is called:
(a) Photorespiration (b) Photo-oxidation
(c) Photoperiodism (d) Phototropism

346. One of the following shows inter-conversion due to red far-red light:
(a) Chlorophylls (b) Carotenoids
(c) Cytochromes (d) Phytochromes

347. What is the effect on the flowering of a plant if a flash of red light is followed by a flash of far-red light?
(a) Flowering is increased
(b) Flowering is decreased
(c) Flowering is stopped
(d) Effect of red-flash is reversed

348. For rooting on leaves of *Bryophyllum*, the growth regulator used is: (BHU 1991)
(a) Indole butyric acid (b) Gibberellic acid
(c) Carotene (d) Lycopene

349. Hormone used in early ripening of fruit is: (BHU 1995)
(a) Auxin (b) ABA
(c) Ethylene gas (d) Cytokinin

350. Apical dominance is caused by: (BHU 1995)
(a) Auxin (b) Gibberellin
(c) Kinetin (d) ABA

351. Maximum auxin concentration in oat coleoptile is found in: (CPMT 1994)
(a) Tip (b) All along the length
(c) In the middle (d) At the base

352. Which of the following is a gaseous plant growth regulator? (BHU 1994)
(a) Ethylene (b) Kinetin
(c) GA (d) ABA

353. Requirement of cold treatment for flowering is called: (CPMT 1994)
(a) Photoperiodism (b) Vernalization
(c) Scarification (d) None of these

354. A key role is played in apical dominance by: (CPMT 1994)
(a) IAA (b) IBA
(c) NAA (d) 2,4-D

355. In decapitated plants, axillary buds are activated because: (CBSE 1994)
(a) Amount of cytokinin increases in them
(b) Auxin is made available to them
(c) They get more light
(d) More food material is available to them

356. Flowering dependent on cold treatment is known as: (CBSE 1992)
(a) Cryoscopy (b) Cryostat
(c) Vernalization (d) Thermotrophy

357. The inherent capacity of an isolated cell to grow into a new individual is termed:
(a) Totipotency (b) Rejuvenation
(c) Immortality (d) Fragmentation

358. Hormone responsible for vernalization is:
(a) Abscisin (b) Vernalin
(c) Florigen (d) Colchicine

359. Photoperiodism in plants is related to the formation of: (AFMC 1993)
(a) Auxin (b) GA_3
(c) Florigen (d) Chlorophyll

360. Which of the following hormones can replace vernalization? (MDAT Bihar 1995)
(a) Auxins (b) Gibberellins
(c) Ethylene (d) Cytokinin

361. Induction of flowering by low temperature in plants is: (BHU 1995)
(a) Vernalization (b) Photoperiodism
(c) Pruning (d) Cryobiology

362. Flowering in long day plants is favoured by: (CPMT 1994)
(a) Gibberellic acid (b) Auxins
(c) Ethylene (d) Cytokinins

363. Which of these helps in fruit ripening? (CPMT 1994)
(a) IAA (b) Gibberellins
(c) Ethylene (d) Cytokinins

364. The ripening of fruits can be hastened by treatment with: (MPPMT 1994)
(a) Gibberellic acid (b) Indole acetic acid
(c) Florigen (d) Ethylene gas

365. Who discovered the technique of converting winter variety into spring variety, *i.e.*, vernalization? (Raj. PMT 1991)
(a) F.W. Went (b) Lysenko
(c) Garner and Allard (d) Hendricks

366. When night temperature is less occurring in winter season the size of potato tuber will:
(a) Decrease
(b) Increase
(c) Increase and decrease both
(d) No effect

367. Chemical agent which has important role in flowering is: (CBSE 1991)
(a) Flurocarbon (b) GA_3
(c) Florigen (d) Auxin

368. The pigment responsible for photomorphogenetic response is: (BHU 1994)
(a) Xanthophyll (b) Chl.b
(c) Cytochrome (d) Phytochrome

369. The phenomenon of vernalization was described for the first time by:
(a) Went (b) Lysenko
(c) Kurosawa (d) Aristotle

370. In many plants the change over from vegetative to reproductive phase takes place in response to:
(a) The oxygen present in the air
(b) The severity of temperature
(c) The length of the day
(d) Mainly the food material available in the soil

371. Which of the following factors influence the flowering in plants? (BHU 1990)
(a) Acidity of soil
(b) Water in soil
(c) Amount of green pigment
(d) Photoperiod

372. The stimulus of vernalization is received in annuals and biennials by: (AIIMS 1991)

(a) Dry seeds (b) Roots
(c) Stem apex (d) Leaves

373. The effect of day length on plant development is called: **(Re. Ex. CPMT 1991)**
(a) Photosynthesis (b) Photoperiodism
(c) Phototropism (d) Chemotropism

374. Ethylene is: **(MDAT Bihar 1995)**
(a) Gaseous growth hormone in plants
(b) Gaseous enzyme
(c) Liquid gas mixture
(d) Solid hormone

375. Which one of the following responses of plants to growth hormones is true for ethylene? **(MPPMT 1995)**
(a) Increase in cell elongation
(b) Decrease in the formation of female flowers
(c) Increase in ripening of fruits
(d) Decrease in abscission of flowers

376. Removal of apical bud during flowering results in: **(CPMT 1993)**
(a) Death of the plant
(b) Formation of new apical bud
(c) Promotion of lateral branching
(d) Elongation of main stem

377. Growth is primarily affected by two climatic factors which are:
(a) Light and temperature
(b) Temperature and relative humidity
(c) Light and wind
(d) Rainfall and temperature

378. Phytotron is a device by which: **(CPMT 1997)**
(a) Plants are grown in controlled environment
(b) Mutations are produced in plants
(c) Electrons are bombarded
(d) Protons are liberated

379. Apical dominance in higher plants is due to:
(a) Hormones (b) Enzymes
(c) Carbohydrates (d) Photoperiodism

380. The instrument by which the rate of growth of stem is accurately measured is:
(a) Potometer (b) Auxanometer
(c) Osmometer (d) Porometer

381. Substances which originate at the tip of stem and control growth elsewhere are:
(a) Food material (b) Auxins or hormones
(c) Vitamins (d) Enzymes

*382. Ethylene gas:
(a) Slows down ripening of apples
(b) Speeds up maturation of fruits
(c) Is saturated hydrocarbon
(d) Retards ripening of tomatoes

383. The ripening of fruits can be accelerated by:
(a) Artificially adding ethylene gas to the atmosphere surrounding them
(b) Warming up the surrounding artificially
(c) Reducing the supply of water to plant when fruits are maturing
(d) Increasing the supply of nitrogen to the atmosphere surrounding them

384. With which of the process the Cholodny-Went theory is concerned? **(MPPMT 1990)**
(a) Photomorphogenesis (b) Photoperiodism
(c) Photorespiration (d) Phototropism

385. Garner and Allard are related with:
(a) Photolysis (b) Photophosphorylation
(c) Phototropism (d) Photoperiodism

386. By hormone application it is possible to obtain seedless fruits. In which of the following it is desirable to obtain seedless fruits?
(a) Tomato (b) Orange
(c) Watermelon (d) Pomegranate (Anar)

387. When the dark period of short day plant is interrupted by a brief exposure of light then the plant:
(a) Flowers immediately
(b) Turns into a long day plant
(c) Will not flower at all
(d) Gives more flower

388. In decapitated plants, axillary buds are activated because: **(CBSE 1994)**
(a) Amount of cytokinin increases in them
(b) Auxin is made available to them
(c) They get more light
(d) More food material is available to them.

389. What happens when dark period of a short day plant is interrupted by a flash of red-light?
(a) Flowering would increase
(b) Flowering would not occur
(c) Size of flower would become large
(d) None of the above

390. *Avena* coleoptile test is associated with which of the following botanist?
(a) F.W. Went (b) F.C. Steward
(c) D.I. Arnon (d) F.F. Blackman

391. Vernalization is:
(a) Flower induction by low temperature treatment of moist seeds
(b) Growth curvature in response of light
(c) Cycles of day and night
(d) Effect of day length on plant growth

392. Pigment involved in photo-perception in flowering is: **(BHU 1991)**
(a) Cytochrome (b) Carotene
(c) Lycopene (d) Phytochrome

393. To prevent over-ripening of banana: **(CBSE 1992)**
(a) Should be kept in refrigerator
(b) Should be kept at room temperature
(c) Should be treated with ascorbic acid
(d) None of the above

394. In short day plants (SDP) flowering is induced by: **(CBSE 1992)**
(a) Long night
(b) Photoperiod less than 12 hours
(c) Photoperiod shorter than initial value and uninterrupted long night
(d) Short photoperiod and interrupted long night

395. Several horticultural techniques are followed for the production of 'Bonsai' plants. One of them is drastic pruning of root system. Which of the following physiological factors is involved in that method? **(CBSE 1990)**
(a) Inadequancy of mineral nutrients
(b) Deficiency of auxins
(c) Impairment of water absorption
(d) Deficiency of cytokinins

396. The term bioassay implies:
(a) Writing an essay on living organisms
(b) Using living organism in testing the biologically active chemicals
(c) Description of micro organisms
(d) Description of useful plant parts

397. Phytochrome is associated with: **(MPPMT 1993)**
(a) Absorption of blue light by leaves
(b) Absorption of red and far-red in reversible manner
(c) Absorption of red light with wave-length $660\,\mu$
(d) Absorption of far-red light with wave length $740\,\mu$

398. What does vernalization mean? **(MPPMT 1990)**
(a) Low temperature treatment
(b) High temperature treatment
(c) Low temperature treatment followed by high temperature
(d) High temperature treatment followed by low temperature

399. The practice of subjecting seeds to low temperature for a period of time in order to cause growth and flowering during summer season is called:
(a) Wintering (b) Vernalization
(c) Devernalization (d) Thermolysis

400. The flowering in short day plants does not take place, when: **(BHU 1994)**
(a) The critical dark period is interrupted by white or red light
(b) An uninterrupted critical dark period
(c) The critical period is interrupted by light
(d) Dark period is interrupted by red light followed by far red light

401. *Cuscuta* is a: **(CPMT 1994)**
(a) Parasite (b) Saprophyte
(c) Epiphyte (d) Symbiont

402. Germination of the seed is promoted by: **(AFMC 1996)**
(a) Green light (b) Red light
(c) Blue light (d) Infra red light

403. All the cytokinins are: **(MPPMT 1996)**
(a) Acidic (b) Aminopurines
(c) Phenol (d) Glucosides

404. Which one of the following hormones is not found in plants: **(MPPMT 1996)**
(a) 2,4-D (b) GA_3
(c) Gibberellin (d) IAA

405. Leaf fall starts when the amount of: **(MPPMT 1996)**
(a) Auxin increases
(b) Auxin decreases
(c) Abscisic acid decreases
(d) Gibberellic acid decreases

406. A genetically dwarf plant can be converted into a tall plant by the use of: **(MPPMT 1996)**
(a) Kinetin (b) GA_3
(c) IAA/X-rays (d) 2,4-D

407. Most of the plants are seasonal due to: **(MPPMT 1997)**
(a) Photoperiodism (b) Phototropism
(c) Photosynthesis (d) Photolysis

408. Certain chemical substances having profound effect on growth, are called: **(MPPMT 1997)**
(a) Catalytic agents (b) Phytohormones
(c) Enzymes (d) Compost

409. The chemical nature of kinetin is: **(AIIMS 1996; Pondicherry 1996)**
(a) Butyric acid
(b) Indole butyric acid
(c) 6-furfuryl amino purine
(d) Indole acetic acid

410. A pigment concerned with both floral induction and seed germination is: **(Pondicherry 1996; MPPMT 2002)**
(a) Florigen (b) Chlorophyll
(c) Plastocyanin (d) Phytochrome

411. The stored food in germinating cotton seeds is acted upon by: **(MPPMT 1996)**
(a) Diastase (b) Lipase
(c) Maltase (d) Trypsin

412. The maximum absorption of visible light in the red region of the spectrum by phytochromes takes place at: **(AFMC 1997)**
(a) 600 nm (b) 650 nm
(c) 660 nm (d) 730 nm

413. Which of the following is a growth retardant? **(MPPMT 1996)**
(a) Adenine (b) Ascorbic acid
(c) Morphactin (d) Zeatin

414. Which of the following hormones owes its discovery to tissue culture technique? **(AMU 1997)**
(a) Auxin (b) Gibberellin
(c) Cytokinin (d) Abscisic acid

415. Induction of formation of interfascicular cambium is by: **(Pondicherry 1996)**
(a) Kinetin (b) Gibberellin
(c) Auxin (d) Ethylene

416. The hormone which has negative effect on apical dominance is: **(AIIMS 1996)**
(a) Auxin (b) Gibberellin
(c) Cytokinin (d) Ethylene

417. The trace gas which is produced in rice paddies and is associated with global warming: **(AIIMS 1992, 97)**
(a) Methane (b) Chlorine
(c) Carbon dioxide (d) Hydrogen sulphide

418. What will be the effect on phytochrome in a plant subjected to continuous red light? **(CBSE 1997)**
(a) Level of phytochrome decreases
(b) Phytochrome is destroyed
(c) Phytochrome synthesis increases
(d) Destruction and synthesis of phytochrome remain in equilibrium

*419. Auxin (IAA) was isolated by Thimann in 1935 from: **(CET Chandigarh 1997)**
(a) Bryophytes (b) Algae
(c) Fungi (d) Pteridophytes

420. If a tree flowers thrice in year (Oct, Jan, July) in northern India, it is said to be: **(CBSE 1997)**
(a) Photosensitive but thermoinsensitive
(b) Thermosensitive but photoinsensitive
(c) Photo and thermosensitive
(d) Photo and thermoinsensitive

421. Gibberellins induce: **(AFMC 1997; Manipal 1997)**
(a) Flowering
(b) Production of hydrolysing enzymes in germinating seeds
(c) Cell division
(d) Hasten leaf senescence.

422. Which of the following fungus is associated with the discovery of Gibberellins? **(Pb. PMT 1997)**
(a) *Fusarium moniliformae* (b) *Fusarium solanii*
(c) *Fusarium oxysporum* (d) *Fusarium longipes*

~~423. Which natural plant hormone regulates the growth of~~ plant?
(a) Ethylene (b) NAA
(c) 2,4-D (d) IBA

424. The most sensitive part of coleoptile is: **(CPMT-1997)**
(a) Tip of coleoptile (b) Just below the tip
(c) Whole part (d) None of these

425. Which auxin does not cause rooting? **(CPMT 1997)**
(a) 2,4-D (b) IAA
(c) NAA (d) IBA

426. Which of the following is natural auxin? **(CPMT 1997)**
(a) IAA (b) NAA
(c) 2,4-D (d) IBA

427. Flowering in SDP is caused by: **(CPMT 1997)**
(a) Cytokinin (b) Gibberellin
(c) Ethylene (d) Auxin

428. 2,4-D is a: **(BHU 1997)**
(a) Insecticide (b) Weedicide
(c) Fungicide (d) Rodenticide

429. Which of the following gas is a growth regulator? **(BHU 1997)**
(a) Acetylene (b) Ethylene
(c) Benzene (d) Methane

430. Which hormones promote the flowering in long day plants and also control sex expression to contain space war?
(a) Cytokinins (b) Gibberellins
(c) Ethylene (d) Auxins

431. Which of the following is a true statement?
(a) Etiolation and albinism are synonyms
(b) Etiolation is genetic while albinism is physiological
(c) Etiolation is not reversible
(d) Etiolation is physiological while albinism is genetic

432. Chemical playing role in abscission is: **(CPMT 1998)**
(a) ABA (b) Auxin
(c) Gibberellin (d) Ascorbic acid

433. Tropic movement takes place mainly by: **(CPMT 1998)**
(a) Cell enlargement (b) Cell bending
(c) Cell division (d) Cell dormancy

434. In drought which hormone plays a protective role? **(CPMT 1998)**
(a) Abscisic acid (b) Gibberellin
(c) Auxin (d) Cytokinin

435. A plant hormone used for inducing morphogenesis in plant tissue culture is: **(CBSE 1998)**
(a) Abscisic acid (b) Gibberellins
(c) Cytokinins (d) Ethylene

436. The response of different organisms to environmental rhythms of light and dark periods is called: **(CBSE 1998)**
(a) Vernalization (b) Phototaxis
(c) Photoperiodism (d) Phototropism

437. Which combination of gases is suitable for fruit ripening? **(CBSE 1998)**
(a) 80% C_2H_4 and 20% CO_2
(b) 80% CO_2 and 20% CH_2
(c) 80% CH_4 and 20% CO_2
(d) 80% CO_2 and 20% O_2

438. What is Agent Orange? **(CBSE 1998)**
(a) A hazardous chemical used in luminous paints
(b) Colour used in fluorescent lamps
(c) A weedicide containing dioxin
(d) A biodegradable insecticide

439. Which one among the following chemicals is used for causing defoliation of forest trees? **(CBSE 1998)**
(a) Amo 1618
(b) Phosphon-D
(c) Malic hydrazide
(d) 2,4-Dichlorophenoxy acetic acid

440. The hormone which controls cell division and cell differentiation is: **(AFMC 1998)**
(a) ABA (b) Auxin
(c) Gibberellin (d) Cytokinin

441. Thigmotropism is best exhibited by: **(AFMC 1998; BHU 1999)**
(a) Root apex (b) Tendrils
(c) Thorns (d) Lamina

442. The largest sized flower of the world is produced by a plant which is a: **(CBSE 1999)**
(a) Epiphyte (b) Partial stem parasite
(c) Total root parasite (d) Conifer

443. Exponential growth of cells is characteristic feature of: **(CBSE 1999)**
(a) Tissue culture cells (b) Multicellular organisms
(c) Unicellular organisms (d) Embryo

444. Which pair of plants derive nitrogen from insects? **(CBSE 1999)**
(a) *Cascuta* and *Cladonia*
(b) *Drosera* and *Rafflessia*
(c) *Aldrovanda* and *Utricularia*
(d) *Nepenthes* and *Viscum*

445. Which plant hormone is artificially synthesized? **(CPMT 1999)**
(a) IAA (b) 2,4-D
(c) 6-furfurylaminopurine (d) None of these

446. Plant's reaction to stimulus of light is called: **(CPMT 1999)**
(a) Photoperiodism (b) Phototropism
(c) Geotropism (d) Hydrotropism

447. Which mineral is required for synthesis of auxins during plant growth? **(CPMT 1999)**
(a) Manganese (b) Zinc
(c) Copper (d) Boron

448. Obligate root parasite is: **(BHU 1999)**
(a) *Rafflessia* (b) *Santalum*
(c) *Cuscuta* (d) None of these

*449. ABA performs: **(BHU 1999)**
(a) Promotes senescence
(b) Does not promote tuber sprouting
(c) Both (a) and (b)
(d) None of the above

450. The hormone responsible for ageing and for causing leaf fall is: **(AIIMS 1999)**
(a) IAA (b) GA
(c) ABA (d) Kinetin

451. Gibberellin is helpful in: **(MPPMT 1999)**
(a) Elongation of plants (b) Inducing dwarfism
(c) Fat hydrolysis (d) Protein synthesis

452. The presence of auxins in a solution could be tested by: **(MPPMT 1999)**
(a) *Avena sativa* stem tip test
(b) Carbon tetrachloride test
(c) Iodine test
(d) Defoliation test

453. Insectivorous plants grow in soils deficient in: **(CBSE 1999; CPMT 2001)**
(a) Potassium (b) Nitrogen
(c) Calcium (d) Water

454. The pigment involved in photomorphogenetic moments is: **(BHU 2000; Kerala PMT 2002)**
(a) Phytochrome (b) Cytochrome
(c) Chlorophyll (d) Xanthophyll

455. What does coconut water contain often used in tissue culture? **(CBSE 2000)**
(a) Gibberellin (b) Auxin
(c) Cytokinin (d) ABA

*456. What will happen, if terminal bud of a plant is removed? **(CBSE 2000)**
(a) The plant will die
(b) The lateral buds will grow
(c) The shoot will die
(d) All its leaves will fall

457. ABA causes: **(CPMT 2000)**
(a) Faster leaf fall (b) Dormancy of tuber
(c) Retardation of growth (d) All of these

458. Which plant hormone induces cell division? **(AFMC 2000)**
(a) Cytokinin (b) GA
(c) Ethylene (d) Auxin

459. High concentration of auxin is present in: **(MPPMT 2000)**
(a) Root apex (b) Shoot apex
(c) Node (d) Petiole

460. Which of the following is used for fruit ripening on commercial scale? **(CET Karnataka 2000)**
(a) 2,4-D (b) 2,4,5-T
(c) IAA (d) Ethylene

461. Match the names of the scientists given under column-I with the areas of contributions given under column-II: choose the answer which gives the correct combination of the alphabets:

	Column-I (scientists)		Column-II (contributions)
A	Dixon and Jolly	p	Photosynthesis
B	Munch	q	Photoperiodism
C	Levitt	r	Stomatal mechanism
D	Garner and Allard	s	Translocation of solutes
		t	Ascent of sap

(CET Karnataka 2000)
(a) A = t, B = s, C = q, D = r
(b) A = t, B = r, C = s, D = q
(c) A = s, B = t, C = q, D = r
(d) A = t, B = s, C = r, D = q

462. Curling of tendrils is due to: **(AIIMS 2000)**
(a) Nyctinastic (b) Phototropism
(c) Heliotropism (d) Thigmotropism

463. Induction of cell division and delay in senescence is done by: **(AIIMS 2001)**
(a) Auxin (b) Kinetin
(c) Gibberellin (d) Cytokinin

464. Photoperiodism affects: **(MPPMT 2001)**
(a) Vegetative growth (b) Internode elongation
(c) Seed germination (d) All of these

*465. Apical dominance is not affected by: **(MPPMT 2001)**
(a) Indole acetic acid (b) Gibberellins
(c) Indole acetaldehyde (d) Indole butyric acid

466. The plants respond to photoperiods due to presence of: **(CET Karnataka 2001; CBSE 2001)**
(a) Stomata (b) Phytochromes

(c) Phytohormones (d) Enzymes

467. This is an insectivorous plant? **(CET Karnataka 2001)**
(a) *Eichhornia* (b) *Opuntia*
(c) *Crotolaria* (d) *Utricularia*

***468.** The stimulus for geotropism in roots is perceived by: **(Uttaranchal PMT 2001)**
(a) Root cap (b) Quiescent centre
(c) Root tip (d) None of these

469. Gibberellin was first of all isolated from: **(Uttaranchal PMT 2001)**
(a) Virus (b) Fungus
(c) Bacteria (d) Lichen

***470.** Roots of which plant contain a red pigment which has affinity for oxygen? **(CBSE 2001)**
(a) Carrot (b) Soybean
(c) Mustard (d) Radish

471. Which breaks dormancy of potato tuber? **(CBSE 2001)**
(a) Gibberellin (b) IAA
(c) ABA (d) Zeatin

472. Hormone responsible for senescence is: **(CBSE 2001)**
(a) ABA (b) Auxin
(c) GA (d) Cytokinin

473. Which of the following prevents the fall of fruits? **(CBSE 2001)**
(a) GA_3 (b) NAA
(c) Ethylene (d) Zeatin

474. Which plant is LDP? **(CBSE 2001)**
(a) Tobacco (b) *Glycine max*
(c) *Mirabilis jalapa* (d) Spinach

475. Which of the following hormones helps in breaking seed dormancy? **(Manipal 2001)**
(a) Gibberellin (b) Auxin
(c) Cytokinin (d) ABA

476. Which can be used as herbicide? **(Manipal 2001)**
(a) DDT (b) 2,4-D
(c) IAA (d) AMP

477. Which of the following is correctly matched? **(Manipal 2001)**
(a) Tomato—day neutral plant
(b) Radish—short day plant
(c) Dahlia—long day plant
(d) Gulmohar—day neutral plant

478. Which of the following is the stress hormone? **(BHU 2001)**
(a) IAA (b) IBS
(c) ABA (d) 2,4-D

479. Which among the following is a synthetic plant hormone? **[BCECE (P.T. Exam.) 2001]**
(a) IAA (b) GA
(c) 2,4-D (d) ABA

480. Which of the following pigments is found in two forms? **(CPMT 2002)**
(a) Phytophore (b) Phytochrome
(c) Cytochrome (d) Chlorophyll

481. Opening of flower and drooping of bud is an example of: **(CPMT 2002)**
(a) Hyponasty (b) Epinastic movement
(c) Movement of curvature (d) Phototactic movement

482. ABA is involved in: **(CPMT 2002)**
(a) Shoot elongation (b) Root elongation
(c) Dormancy of seeds (d) Increased cell division

483. First natural cytokinin, zeatin was discovered by: **(CET J&K 2002)**
(a) Letham (b) Skoog & Miller
(c) Bensen (d) Thimann and Went

484. Insectivorous plants can grow well in a soil deficient in: **(JIPMER 2002; BV Pune 2003)**
(a) Magnesium (b) Iron
(c) Calcium (d) Nitrogen

485. Coleoptile auxin was: **(JIPMER 2002)**
(a) Indole-3-butyric acid (b) Indole-3-lactic acid
(c) Indole-2-acetic acid (d) Indole-3-acetic acid

486. To promote the growth of lateral branches of a plant: **(CET Karnataka 2002)**
(a) Apical bud is removed
(b) Axillary buds are removed
(c) Auxin is applied to the decapitated shoot tip
(d) Auxin is applied to the apical bud

487. Bud dormancy is induced by: **(AIIMS 2002)**
(a) ABA (b) IAA
(c) Ethylene (d) GA

488. A plant hormone used for inducing morphogenesis in plant tissue culture is: **(AFMC 2002)**
(a) Ethylene (b) Gibberellin
(c) Cytokinin (d) Abscisic acid

489. Which pigment absorbs the red and far red light? **(CBSE 2002)**
(a) Cytochrome (b) Phytochrome
(c) Carotenoids (d) Chlorophyll

490. Choose the correct match:
Bladderwort, sundew, venus fly trap **(CBSE 2002)**
(a) *Nepenthes, Dionaea, Drosera*
(b) *Nepenthes, Utricularia, Vanda*
(c) *Utricularia, Drosera, Dionaea*
(d) *Dionaea, Trapa, Vanda*

***491.** Sleeping movements in *Samanea saman* leaves are regulated by: **(EAMCET 2002)**
(a) Nitrogen (b) Potassium
(c) Phosphorus (d) Magnesium

***492.** Exposure to light inhibits the process of germination in the seeds of following plant: **(EAMCET 2002)**
(b) *Allium* (b) *Lactuca*
(c) *Capsella* (d) *Nicotiana*

493. Genetic dwarfism can be overcome by: **(Orissa JEE 2002)**
(a) Auxin (b) Gibberellin
(c) ABA (d) Ethylene

494. Which one of the following plant hormone is extracted from fungus? **(CPMT 2003)**
(a) Auxin (b) Gibberellin
(c) Cytokinin (d) 2,4,D

495. Highest concentration of auxin is found in: **(CPMT 2003)**
(a) Root and shoot tips (b) Leaves and fruits
(c) Mid stem portion (d) None of these

496. Ethylene is used for: **(CPMT 2003)**
(a) Decrease the senescence
(b) Increase the heights of stem
(c) Ripening of fruits
(d) Prevention of leaf fall

497. *Cuscuta* is a: **(CPMT 2003)**
(a) Parasitic plant (b) Symbiotic plant
(c) Predator (d) Decomposer

498. The movement of pollen tube is called: **(CPMT 2003)**
(a) Chemotropism (b) Thermotaxis
(c) Thermonastic (d) Hydrotropism

499. Combination of auxin with another plant growth regulator is used in the culture technique. What is that another hormone? **(BHU 2003)**
(a) Ethylene (b) Gibberellin
(c) Caumarins (d) Cytokinin

500. The growth regulator associated with drought stress tolerance is: **(Orissa JEE 2003)**
(a) Auxin (b) Kinetin
(c) Gibberellic acid (d) Abscisic acid

501. The receptor molecule in plants that responds to changes in light is: **(Orissa JEE 2003)**
(a) Phytochrome (b) Cytochrome
(c) Ferredoxin (d) Vernalin

502. The movement in touch me not plant induced by touch is: **(Orissa JEE 2003)**
(a) Chemotropic (b) Seismonastic
(c) Phototactic (d) Epinastic

503. Cytokinins are formed in: **(DPMT 2003)**
(a) Roots (b) Leaves
(c) Fruits (d) Stems

504. To remove seed dormancy by mechanical removing of seed coat is called: **(DPMT 2003)**
(a) Stratification (b) Scarification
(c) Vernalization (d) Photoperiodism

505. Vernalization is done at: **(DPMT 2003)**
(a) Lower temperature (b) Low light intensity
(c) Higher temperature (d) High light intensity

506. The hormone involved in metabolism of food material in cereal grain during germination is: **(DPMT 2003)**
(a) Auxin (b) CKN
(c) GA (d) None of these

507. Synthetic auxins are used for: **(Kerala PMT 2003)**
(a) Killing weeds
(b) Ripening fruits
(c) Increasing the size of the fruits
(d) Stimulating growth of cells in tissue culture
(e) Preventing elongation of internodes

508. Photoperiodism in plants is governed by: **(Kerala PMT 2003)**
(a) Gibberellins (b) Florigen
(c) Phytochromes (d) Cytochrome
(e) Cytokinesis

509. The rate of growth in plants is measured using this instrument: **(Kerala PMT 2003)**
(a) Potometer (b) Auxanometer
(c) Photometer (d) Hygrometer
(e) Spectrometer

ANSWERS

1—c	2—b	3—b	4—c	5—c	6—c	7—c	8—a	9—d	10—b	11—d	12—c
13—c	14—b	15—b	16—c	17—c	18—b	19—d	20—c	21—c	22—b	23—b	24—d
25—c	26—b	27—d	28—b	29—c	30—d	31—a	32—a	33—b	34—c	35—c	36—c
37—b	38—c	39—c	40—b	41—b	42—c	43—b	44—d	45—c	46—c	47—c	48—b
49—d	50—b	51—d	52—c	53—b	54—d	55—d	56—c	57—c	58—d	59—b	60—c
61—c	62—c	63—d	64—b	65—c	66—c	67—c	68—b	69—b	70—c	71S—b	72—b
73—c	74—d	75—a	76—c	77—a	78—a	79—d	80—a	81—a	82—a	83—d	84—d
85—c	86—b	87—b	88—d	89—b	90—a	91—d	92—c	93—d	94—c	95—a	96—b
97—c	98—b	99—b	100—a	101—a	102—b	103—b	104—c	105—b	106—d	107—d	108—b
109—a	110—c	111—d	112—a	113—c	114—a	115—c	116—a	117—a	118—c	119—d	120—a
121—d	122—d	123—c	124—c	125—b	126—c	127—b	128—c	129—c	130—d	131—b	132—c
133—a	134—d	135—b	136—a	137—c	138—b	139—c	140—b	141—a	142—b	143—b	144—a
145—b	146—d	147—a	148—a	149—d	150—d	151—d	152—b	153—c	154—a	155—c	156—c
157—a	158—a	159—b	160—d	161—d	162—a	163—a	164—b	165—b	166—d	167—b	168—c
169—c	170—c	171—b	172—a	173—b	174—b	175—d	176—c	177—a	178—a	179—b	180—d
181—a	182—b	183—b	184—c	185—d	186—a	187—a	188—d	189—d	190—a	191—a	192—c

193—b	194—b	195—a	196—d	197—c	198—d	199—d	200—c	201—c	202—b	203—b	204—d
205—d	206—b	207—b	208—c	209—d	210—a	211—c	212—a	213—b	214—c	215—b	216—c
217—a	218—d	219—a	220—b	221—c	222—b	223—a	224—a	225—c	226—a	227—c	228—a
229—c	230—c	231—d	232—b	233—c	234—a	235—d	236—b	237—b	238—a	239—c	240—b
241—d	242—b	243—c	244—c	245—a	246—c	247—a	248—d	249—c	250—a	251—b	252—c
253—b	254—c	255—c	256—a	257—b	258—a	259—a	260—d	261—c	262—b	263—a	264—c
265—b	266—b	267—a	268—b	269—d	270—d	271—b	272—b	273—a	274—b	275—a	276—c
277—b	278—a	279—c	280—a	281—a	282—c	283—b	284—d	285—a	286—c	287—b	288—d
289—a	290—d	291—d	292—b	293—d	294—b	295—d	296—b	297—a	298—c	299—a	300—c
301—c	302—d	303—b	304—b	305—b	306—a	307—d	308—d	309—c	310—b	311—c	312—d
313—c	314—c	315—b	316—a	317—b	318—c	319—c	320—d	321—d	322—c	323—c	324—b
325—b	326—a	327—a	328—b	329—c	330—a	331—c	332—a	333—a	334—c	335—b	336—d
337—c	338—b	339—d	340—c	341—a	342—c	343—a	344—b	345—c	346—d	347—d	348—d
349—c	350—a	351—a	352—a	353—b	354—a	355—a	356—c	357—a	358—b	359—c	360—b
361—a	362—a	363—c	364—d	365—b	366—b	367—c	368—d	369—b	370—c	371—d	372—c
373—b	374—a	375—c	376—c	377—a	378—a	379—a	380—b	381—b	382—b	383—a	384—d
385—d	386—c	387—c	388—a	389—b	390—b	391—a	392—d	393—c	394—c	395—c	396—b
397—b	398—a	399—b	400—a	401—a	402—b	403—b	404—a	405—b	406—b	407—a	408—b
409—c	410—d	411—b	412—c	413—c	414—c	415—a	416—c	417—a	418—d	419—c	420—d
421—b	422—a	423—a	424—a	425—a	426—a	427—a	428—b	429—b	430—b	431—d	432—a
433—a	434—a	435—c	436—c	437—a	438—c	439—d	440—d	441—b	442—c	443—c	444—c
445—b	446—b	447—b	448—a	449—c	450—c	451—a	452—a	453—b	454—a	455—c	456—b
457—d	458—a	459—b	460—d	461—d	462—d	463—d	464—d	465—b	466—b	467—d	468—a
469—b	470—b	471—a	472—a	473—b	474—d	475—a	476—b	477—a	478—c	479—c	480—b
481—b	482—c	483—a	484—d	485—d	486—a	487—a	488—c	489—b	490—c	491—b	492—a
493—b	494—b	495—a	496—c	497—a	498—a	499—d	500—d	501—a	502—b	503—a	504—b
505—a	506—c	507—a	508—c	509—b							

EXPLANATION OF SELECTED QUESTIONS (*)

82. IAA is the hormone involved in phototropism according to Cholodny-Went theory.

89. As auxins are responsible for apical dominance and thus inhibit the growth of lateral axillary buds.

107. Barley seeds are associated with α-amylase bioassay of gibberellins.

159. Circulation movements of cyclosis can be best observed in staminal hairs of *Tradescantia*.

173. Foolish disease or bakanae disease of rice in Japan is associated with discovery of gibberellins.

177. As antherozoids show locomotion movements under the influence of chemicals, so these are chemotactic movements.

186. Sleep or nyctinastic movements are caused due to daily rythms of light and dark.

206. Coconut milk or liquid endosperm of *Cocos nucifera* is having cytokinins and hence used in culture media.

227. Root meristem is sub-apical in position due to presence of root cap.

244. Gas chromatography is nowadays used in separation and identification of phytohormones.

254. GA treatment of dwarf plant changes only its phenotype and not genotype.

318. Etiolation occurs in dark or absence of light.

329. Delay in senescence by cytokinins is called Richmond-Lang effect.

332. A plant which flowers in photoperiods more than critical day length is LDP.

344. DCMU is a strong inhibitor of PS-II.

382. As ethylene induces climacteric, hence it speeds up maturation or ripening of fruits.

419. Thimann isolated IAA from *Rhizopus suinus* (fungus).

449. ABA promotes senescence as well as induces dormancy of seeds and tubers.

456. When terminal bud of a plant is removed, apical dominance is removed and thus lateral buds will grow.

465. Apical dominance is caused due to auxins and not due to gibberellins.

468. In root, geotropic response is perceived by root cap.

470. A red pigment called leghaemoglobin is present in root nodules of leguminous plants.

491. Sleeping movements in *Samanea saman* leaves are regulated by Potassium.

492. *Allium* seeds are negatively photoblastic.

TEST PAPER–UNIT–7

1. Water potential of pure water and its solution are:
   (a) 0 and 1 (b) –0 and 0
   (c) 0 and more than 0 (d) 0 and less than 0
2. What will be zero in a fully turgid cell?
   (a) TP (b) WP
   (c) SP (d) OP
3. Cell A has osmotic pot. = – 15 bars and pressure pot. = 8 bars and cell B has osmotic pot. = – 12 bars and wall pressure = 2 bars, what is the direction of flow of water?
   (a) A → B (b) B → A
   (c) A ↔ B (d) No movement
4. Water absorption 'through' the roots is:
   (a) Active absorption (b) Passive absorption
   (c) Both (a) and (b) (d) None of these
5. Root hairs arise from :
   (a) Pericycle (b) Epiblema
   (c) Endodermis (d) Cortex
6. 'Exudation' is due to:
   (a) O.P. (b) Root pressure
   (c) Diffusion pressure (d) Transpiration pull
7. The role of innermost layer of cortex in ascent of sap was proposed by:
   (a) Godlewski (b) Molisch
   (c) J.C. Bose (d) None of these
8. Wilting occurs when:
   (a) Phloem is blocked
   (b) Xylem is blocked
   (c) Both xylem and phloem are blocked
   (d) A few roots are removed
9. Osmotic pressure of cell can be measured by:
   (a) Manometric method (b) Photometric method
   (c) Plasmolytic method (d) Colorimetric method
10. Stomatal transpiration accounts for what percentage of water loss?
   (a) 20% (b) 80-90%
   (c) 70% (d) 75%
11. Guttation is due to:
   (a) O.P. (b) S.P.
   (c) Root pressure (d) T.P.
12. Which is antitranspirant?
   (a) Sodium benzoate (b) $Ca(OH)_2$
   (c) PMA (d) IAA
13. Which ions are responsible for stomatal movements?
   (a) Fe^{2+} (b) Zn^{2+}
   (c) K^+ (d) Na^+
14. Which are required for photolysis of water?
   (a) Zn and Mn (b) Mn and Cl
   (c) Cl and Mg (d) Fe and Mg
15. Which is related with translocation of sugars in plants?
   (a) Zn (b) K
   (c) B (d) Mo
16. Carrier concept of mineral salt absorption was formulated by:
   (a) Lundegardh (b) Bennet Clark
   (c) Vanden Honert (d) None of these
17. Criteria for essentiality of element was given by:
   (a) Woodward (b) Arnon
   (c) de Saussure (d) None of these
18. There is no role of cytochromes in:
   (a) Respiration (b) Photosynthesis
   (c) Salt absorption (d) Transpiration
19. How many oxidation steps are there in aerobic respiration?
   (a) 5 (b) 4
   (c) 2 (d) 1
20. Amount of energy given by 1 mol. of ATP is:
   (a) 721 kcal (b) 7600 kcal
   (c) 1000 kcal (d) 7.3 kcal
21. R.Q. is ...., when fat is respiratory substrate:
   (a) 1 (b) > 1
   (c) < 1 (d) 0
22. C-2 cycle is associated with:
   (a) Respiration
   (b) Photorespiration
   (c) Dark reaction
   (d) Conversion of fat into sugar
23. Most abundant protein on earth is:
   (a) Albumins (b) Plastocyanin
   (c) Rubisco (d) None of these
24. How many H_2O molecules are used in Krebs' cycle?
   (a) 2 (b) 8
   (c) 10 (d) 16
25. Number of ATP and $NADH_2$ produced in photorespiration are:
   (a) 2 and 4 (b) 1 and 2
   (c) 4 and 6 (d) 0
26. Which is non-enzymatic reaction in respiration?
   (a) Phosphoglyceric acid → PEP
   (b) 3-Phosphoglyceraldehyde → 1,3-Diphosphoglyceraldehyde
   (c) Pyruvic acid → Acetyl CoA
   (d) 1, 3-Diphosphoglyceric acid → 3-PGA.
27. When a plant is girdled, which part dies first?
   (a) Leaves (b) Stem
   (c) Root (d) All simultaneously
28. 'Reaction centre' of PS-I is:
   (a) P_{690} (b) P_{682}
   (c) P_{700} (d) None of these
29. 'Red drop' is at:

(a) 620 nm (b) 660 nm
(c) 680 nm (d) Above 680 nm

30. Electron donor to PS-I is:
(a) Cyt. f (b) PC
(c) Cyt. b_6 (d) Fd

31. O_2 evolution and $NADPH_2$ synthesis occurs in:
(a) Cyclic photophosphorylation
(b) Non-cyclic photophosphorylation
(c) Both (a) and (b)
(d) None of the above

32. Which is both C-3 and C-4 plant?
(a) Sugar cane (b) Maize
(c) *Atriplex* (d) *Chenopodium*

33. First carboxylation reaction in C-4 plants occurs in:
(a) Mesophyll chloroplast
(b) Bundle sheath chloroplast
(c) Either of two
(d) None of the above

34. Which are photosynthetically more efficient?
(a) C-3 plants (b) C-4 plants
(c) C-2 plants (d) C-1 plants

35. Chemosynthesis occurs in:
(a) Presence of light (b) Presence of O_2
(c) Absence of O_2 (d) None of these

36. Which is absent in chloroplast?
(a) Chlorophyll- a (b) Carotene
(c) Anthocyanin (d) Xanthophyll

37. Concept of 'Florigen' was given by:
(a) Butler (b) Borthwick
(c) Chailakhyan (d) Allard

38. Site of vernalization is:
(a) Stem (b) Leaf
(c) Root (d) Apical meristem

39. Another name of 'Heteroauxin' isolated by Kogl from human urine is:
(a) IBA (b) IAA
(c) NAA (d) 2,4-D

40. 'α-amylase test' is bioassay of:
(a) Auxins (b) GA
(c) Cytokinin (d) ABA

41. Potent root initiator is:
(a) IAA (b) IBA
(c) NAA (d) None of these

42. Distribution of growth in a root by marking it at equal intervals with India ink was first studied by:
(a) Strasburger (b) Sachs
(c) Nitsch (d) Went

43. RuBP-oxygenase enzyme is associated with:
(a) EMP-pathway
(b) Citric acid cycle
(c) C-3 cycle
(d) C-2 cycle (photorespiration)

44. How many ATP and $NADPH_2$ molecules are needed for synthesis of one hexose molecule (glucose) in C-4 plants?
(a) 12 ATP and 12 $NADPH_2$
(b) 18 ATP and 12 $NADPH_2$
(c) 12 ATP and 30 $NADPH_2$
(d) 30 ATP and 12 $NADPH_2$

45. Which hormone is used for breaking seed dormancy?
(a) IAA (b) GA
(c) Cytokinin (d) ABA

46. First carboxylation reaction in C-4 cycle starts in presence of:
(a) RuBP-carboxylase (b) PEP-carboxylase
(c) RuBP-oxygenase (d) None of these

47. Under anaerobic conditions, net gain of ATP in EMP-pathway is:
(a) 2 ATP (b) 4 ATP
(c) 8 ATP (d) 0 ATP

48. The source of energy for chemosynthetic autotrophs is:
(a) Inorganic substances (b) Organic substances
(c) Both (a) and (b) (d) None of these

49. Which is the hydrogen acceptor in tricarboxylic acid cycle?
(a) NADP (b) NAD
(c) Coenzyme-II (d) None of these

50. Photorespiration is not shown by:
(a) *Sorghum vulgare* (b) *Saccharum officinarum*
(c) *Zea mays* (d) All of these

51. Bolting phenomenon is induced by applying :
(a) Auxins (b) Gibberellins
(c) Ethylene (d) Cytokinins

ANSWERS

1—d	2—c	3—a	4—b	5—b	6—b	7—c	8—b	9—c	10—b	11—c	12—c
13—c	14—b	15—c	16—c	17—b	18—d	19—a	20—d	21—c	22—b	23—c	24—b
25—d	26—b	27—c	28—c	29—d	30—b	31—b	32—c	33—a	34—b	35—b	36—c
37—c	38—d	39—b	40—b	41—b	42—b	43—d	44—d	45—b	46—b	47—a	48—a
49—b	50—d	51—b									

UNIT-7

ASSERTION AND REASON TYPE QUESTIONS

In the questions given below, two statements—an Assertion (A) and a Reason (R) are given. Give the appropriate response as:

(a) If both A and R are true and R is the correct explanation of A.
(b) If both A and R are true and R is not correct explanation of A.
(c) If A is true and R is false.
(d) If both A and R are false.
(e) If A is false and R is true.

1. A : Rate of water absorption decreases below 20°C.
R : Decrease in temperature below 20°C leads to decrease in permeability of membranes, increase in viscosity of H_2O, poor root growth and low metabolic rate.
2. A : Ringing or girdling experiment provides an evidence in favour of xylem as path of ascent of sap.
R : Ringing experiment cannot be performed in monocots.
3. A : Stomata are main avenues for transpiration.
R : Stomata are minute pores present on leaf epidermis.
4. A : Stomata open when guard cells are turgid and close when guard cells are flaccid.
R : Stomatal movements are governed by change in turgidity of guard cells.
5. A : Wind increases the rate of transpiration.
R : Wind dries the external environment and thus increases the vapour pressure gradient between external environment and internal environment of leaf.
6. A : Guttated water is impure.
R : Guttation is due to transpiration pull.
7. A : Guttation is uncontrolled phenomenon.
R : Hydathodes remain always open.
8. A : Plant ash contains only inorganic substances or mineral elements.
R : All the elements present in plant ash are essential.
9. A : C, H, O are called critical elements.
R : Frame work elements are those in which soil is generally deficient.
10. A : Khaira disease of rice is a physiological disease.
R : Zinc deficiency is the cause of Khaira disease in rice.
11. A : Chlorine has important role in light reaction of photosynthesis.
R : Photolysis of water is helped by chlorine.
12. A : Mineral salt absorption is dependent on water absorption.
R : Mineral salt absorption occurs by root hair zone.
13. A : Minerals salts are absorbed mostly in the form of molecules.
R : Path of transport of mineral salts is xylem.
14. A : Very high temperature leads to decrease in mineral salt absorption.
R : Denaturation of protein carriers occurs at very high temperature.
15. A : Respiration is a vital process.
R : Respiration is characteristic of all living cells.
16. A : Glycolysis is the first common step of both aerobic as well as anaerobic respiration.
R : 1 molecule of hexose sugar is converted into 2 molecules of pyruvic acid in absence or presence of oxygen in glycolysis.
17. A : Vegetables and fruits are stored at low temperature.
R : At low temperature, activity of respiratory enzymes is less.
18. A : Injury leads to increase in rate of respiration.
R : More meristematic activity of cells is needed to heal up of the wound which needs more energy.
19. A : Translocation of solutes takes place from higher concentration of its soluble form to lower concentration of its soluble form.
R : Translocation of solutes mostly occurs in the form of glucose.
20. A : Photorespiration is a wasteful phenomenon.
R : No ATP or $NADH_2$ is produced in photorespiration.
21. A : In bacteria, photosynthesis occurs by utilizing wavelengths longer than 700 nm.
R : Here the reaction centre is P-890.
22. A : In fixation of six molecules of CO_2 in photosynthesis, 18 ATP and 12 $NADPH_2$ are used to form one molecule of hexose sugar.
R : The light reaction results in formation of ATP and $NADPH_2$. **(AIIMS 2002)**
23. A : Red drop occurs above 680 nm of light.
R : PS-II becomes inactive above 680 nm.

24. A : For evolution of O_2 in photosynthesis, PS-II is required.
R : PS-II is reduced by pulling electrons from water due to which photolysis of H_2O occurs.

25. A : Dark reaction of photosynthesis occurs only in absence of light.
R : Dark reaction is purely enzymatic reaction.

26. A : 85% of total plants are C-3 plants.
R : C-4 plants are all angiosperms.

27. A : Agranal chloroplasts are present in C-3 plants.
R : Agranal chloroplasts are present in mesophyll cells.

28. A : C-4 plants are photosynthetically more efficient.
R : Photorespiration is absent in C-4 plants.

29. A : Bacterial photosynthesis occurs in presence of light and oxygen.
R : There is only one pigment system in photosynthetic bacteria.

30. A : Chemosynthetic bacteria are aerobic.
R : These utilize chemical energy instead of light energy in manufacturing their food.

31. A : Leaves are the organs of reception of vernalization.
R : As a result of vernalization, a flowering hormone called florigen is formed.

32. A : Growth is a qualitative change.
R : Growth is overall in unicellular plants.

33. A : All growth regulators are natural.
R : All growth regulators are growth promotors.

34. A : Etiolation occurs when plants are kept in dark.
R : Inhibitors of gibberellins called flavanoids are not formed in dark.

35. A : Ethylene is a growth inhibitor.
R : Senescence and abscission are enhanced by ethylene.

36. A : Antherozoids of bryophytes show chemotropic movements.
R : This is a paratonic movement of locomotion.

37. A : Ethylene is involved in ripening of fruits.
R : Ethylene is responsible for early climacteric.

38. A : Photosynthesis is reverse of respiration.
R : Source of liberated O_2 in photosynthesis is CO_2.

39. A : Seed germination is enhanced by GA.
R : α-amylase synthesis is enhanced by gibberellins.

40. A : The gibberellins induce flowering in long day plants.
R : Genetically tall plant becomes dwarf by the action of gibberellins. **(AIIMS 1994)**

41. A : By insectivorous habit, the insectivorous plants fulfil their nitrogen deficiency.
R : All the nitrogen requirements of insectivorous plants are fulfilled through the proteins of insects. **(AIIMS 1995)**

42. A : The sulphur is precipitated in the soil by $FeS\text{-}H_2S$ system.
R : In soil there is oxidation-reduction exchange occurring between sulphate and elemental sulphur. **(AIIMS 1995)**

43. A : In the process of alcoholic fermentation, the hexose molecule is converted into glucose and fructose.
R : Alcoholic fermentation is the respiration in the absence of oxygen brought about by enzyme zymase. **(AIIMS 1996)**

44. A : C-4 pathway is a kind of CO_2 fixation found in some tropical plants.
R : In this pathway CO_2 is fixed by a three carbon compound and ultimately a molecule with 4 carbon atoms is produced. **(AIIMS 1998)**

45. A : Light is a very important external factor of transpiration.
R : Light induces stomatal opening and darkness induces stomatal closure. Thus the rate of transpiration increases in light and decreases in dark. **(AIIMS 1998)**

46. A : Insectivorous habit of plants is to cope with oxygen deficiency.
R : Insectivorous plants are partly autotrophic and partly heterotrophic. **(AIIMS 1998)**

47. A : In short day plant, day length should be less than critical day length.
R : Long night should be continuous. **(AIIMS 1999)**

48. A : Over ripening of fruits is caused by auxins.
R : In some fruits, 2,4-D causes early ripening. **(AIIMS 1999)**

49. A : In plants water moves from higher water potential to lower water potential.
R : Energetically water moves from higher to lower energy. **(AIIMS 2001)**

50. A : Stomata open during the day.
R : Stomata help in gaseous exchange. **(AIIMS 2001)**

ANSWERS

1. (a)	2. (b)	3. (b)	4. (a)	5. (a)	6. (c)	7. (a)	8. (c)	9. (d)	10. (a)
11. (a)	12. (d)	13. (c)	14. (a)	15. (a)	16. (a)	17. (a)	18. (a)	19. (c)	20. (a)
21. (a)	22. (b)	23. (a)	24. (a)	25. (c)	26. (b)	27. (d)	28. (a)	29. (c)	30. (b)
31. (d)	32. (c)	33. (d)	34. (a)	35. (a)	36. (c)	37. (a)	38. (d)	39. (a)	40. (c)
41. (c)	42. (b)	43. (c)	44. (b)	45. (a)	46. (c)	47. (b)	48. (d)	49. (a)	50. (b)

UNIT-8

- Ecology
- Test Paper—Unit–8
- Assertion—Reason Type Questions (Unit–8)

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26

Ecology

- Introduction
- Ecology in India
- Some important ecological terms
- **Ecological factors :** Climatic factors, Topographic factors, Edaphic factors and Biotic factors
- **Ecosystem :** Types, Structure and function, Ecological pyramids, Food chains, Food web, Energy flow in ecosystem, Productivity of ecosystems, Ecological efficiencies, Biogeochemical cycles, Major biomes
- **Water ecological adaptations :** Hydrophytes, Xerophytes, Mesophytes, Halophytes
- Ecological indicators
- Ecological succession
- Soil erosion and soil conservation
- Pollution
- Natural resources
- Biodiversity
- Zonation in a fresh water body.

Nature has two components, organisms and environment. These two components are interacting, interdependent and dynamic. The branch dealing with the principles governing interaction of organisms and environment constitute ecology.

- Ecology (Oikologie, made of two Greek words, *i.e.*, *Oikos*–house or dwelling + *Logos*—study or discourse). Thus literary meaning of ecology is, study of **organisms at their home.**

Ecology can be defined as the branch which deals with inter-relationship between environment and organisms.

The term ecology was first coined by **E. Haeckel** 1868. Although, first used in literature by **H. Reiter.**

ECOLOGY IN INDIA

Ecological studies in India were first started by **Dudgeon** (1921) at **Allahabad,** *i.e.*, ecology of upper gangetic plains. Later on these studies were further elaborated by **Saxton** and **R. Mishra.**

- Some famous Indian ecologists are, **Prof. R. Mishra–Father of Indian ecology, Prof. K.C. Mishra, Prof. R.S. Ambasht** (all at **B.H.U., Varanasi**). Besides **Prof. L.P. Mall, Prof. S.C. Pandeya, Prof. Balakrishnan, Prof. Brij Gopal,** etc.
- Most active centre of ecological studies in India is **B.H.U., Varanasi.**
- In 1971, UNESCO started an inter-governmental programme, *i.e.*, **IBP** (International Biological Programme) and this programme was under the guidance of Prof. R. Mishra in India.
- Another International programme was MAB–Man And Biosphere.

SOME IMPORTANT ECOLOGICAL TERMS

1. Factor (Environmental factor)

Any external force, substance or condition which affects living organism in any way, is known as factor or environmental factor. All these factors together constitute environment or environmental complex.

2. Species

Uniform interbreeding population or group of individuals which freely interbreed among themselves, constitute a species.

- **Keystone species :** A keystone species is a species or set of species whose impact on its community or ecosystem is much larger and more influential (dominating influence) than would be expected from mere abundance. According to Paine (1969), keystone species are those whose role or activities determine community structure.
- Keystone species are most easily recognized by removal experiments.

Originally, keystone species were thought to be top predators such as wolves, whose presence limits the abundance of herbivores and thus reduces their grazing or browsing on plants. But recently it has been recognized that less conspicuous species also play essential community roles, *e.g.*, certain tropical figs, bear fruits during seasons when no other fruits is available for **frugivores** (fruit-eating animals). If these figs are removed, many animals would starve to death during period of food scarcity. With the death of these animals, many plant species that depend on them at other times of the year for pollination and seed dispersal would also disappear.

Even micro-organisms can play vital roles (*i.e.*, act as keystone species), *e.g.*, **mycorrhizae** (fungi associated with roots of higher plants) are essential for mineral absorption and mobilization. If these fungi die, the trees and many other species will also die.

3. Population

Monospecific (same species) group of organisms which live together in more or less similar environmental conditions constitute a population.

4. Community

Polyspecific (many species) group of organisms which live together in more or less similar environmental conditions constitute community.

- The term **biocoenosis** is also used for community, which was coined by **Carl Mobius** (1880).

5. Vegetation

Totality of plants in a particular region is called vegetation and communities are units of vegetation.

6. Flora

Species content of plants of a region (not numerical strength) is known as flora, *i.e.*, flora is listed while vegetation is described.

7. Biome

It is large unit of climax communities present in well defined climatic zone, *e.g.*, **tundra Biome.**

8. Ecotone

It is zone of transition between two types of communities and represents a zone of special ecological interest, *e.g.*, estuary is ecotone between marine and fresh water communities.

- Hypersaline water is found in estuaries.

9. Habitat

A living place of an organism is called its habitat.

10. Ecological niche or Niche

It includes habitat as well as functional role of an organism in the community, *i.e.*, trophic structure. Thus ecological niche is the **profession** of the species.

- Ecological niche is occupied by a population. This term was first used by **Grinnel**.

11. Ecological equivalents

The organisms having similar niche in different geographical regions are known as ecological equivalents, *e.g.*, cow in India and kangaroo in Australia (both herbivores) are ecological equivalents.

12. Autecology

Study of single individual or a population in relation to environment is called autecology.

13. Synecology

Study of group of individuals or a community in relation to environment is known as synecology.

14. Limnology

Study of fresh water ecology is called limnology.

15. Ecades or Ecophenes

Ecades of a species are group of individuals which have similar genetic constitution but appear different due to different environmental conditions, *i.e.*, in ecades variations are not genetically fixed but are environmentally induced.

- If different ecades of a species are grown in similar environmental conditions they will be **similar.**

16. Ecotypes or Physiological races or Ecological races

Ecotypes are the group of individuals which have **different genetic constitution** but on the basis of their inbreeding behaviour, they are placed under same species, *i.e.*, variations in ecotypes are genetically fixed and not environmentally induced, *e.g.*, in *Euphorbia hirta* there are two ecotypes, namely erect type and prostrate type.

- If two ecotypes of a species are grown together in same environmental conditions, they will **remain different.**

17. Ecosystem

The term ecosystem was given by **A.G. Tansley** 1935. The system formed by interactions between community and environment is called ecosystem. Living organisms interact with environment (physical) in such a way that there is flow of energy forming clear trophic levels and material cycles in the system.

- The term **biogeocoenosis** or **geobiocoenosis** is used for ecosystem, coined by **Dokuchaev.**

18. Cybernetics

Science of control of ecosystem is called **cybernetics.** (French *Kybernetes*–pilot or governor).

19. Homeostasis

(*Homo*–same + *Stasis*–condition). Equilibrium state of ecosystem is called homeostasis.

20. Standing state or Standing quality

Amount of inorganic substances present at any time in environment of ecosystem is called standing state.

21. Standing crop

Amount of living material present at any time in environment of ecosystem is called standing crop.

22. Biomass

Standing crop in terms of weight is called biomass.

23. Ecosphere or Biosphere

The whole earth considered as a huge ecosystem is called ecosphere or biosphere.

24. Productivity

Rate of production or organic matter accumulation per unit time in living components of ecosystem is called productivity.

25. Primary productivity

Productivity at producers level is known as primary productivity. It is of two types :

(a) **Gross primary productivity :** Primary productivity including that amount which is utilized in respiration and other metabolic activities.

(b) **Net primary productivity (NPP) :** Primary productivity in excess to that which is utilised in respiration and other metabolic activities.

26. Secondary productivity

Productivity at consumers level is called secondary productivity.

27. Biogeochemical cycles or Material cycles

More or less circular pathways through which different chemical elements present in biosphere move from organism to environment and *vice-versa*, are called biogeochemical cycles, *e.g.*, carbon cycle, nitrogen cycle, sulphur cycle, etc.

28. Remote sensing

Obtaining or getting knowledge of any aspect of ecosystem by means of far away recording instruments is called remote sensing, *e.g.*, by aerial photography, radar, UV and infrared detectors, etc.

29. Biological clocks

The plant species possess certain physiological mechanisms by means of which they indicate particular seasons of the year and thus constitute biological clocks.

30. Ecological indicators or Biological indicators

Living organisms act as index or measure of prevailing environmental conditions and thus they constitute biological indicators.

31. Savannah

Type of grasslands in which trees and shrubs are present at wide intervals are called savannahs. All Indian tropical grasslands are example of savannahs (but not true savannahs).

32. Cosmopolitan

The organisms which are world wide in distribution or are present everywhere are called cosmopolitan.

33. Endemic

The organisms which are restricted to particular area are called endemic.

34. Allopatric species

The species which are present in different geographical regions, separated by spatial barriers are called allopatric species.

35. Sympatric species

The species which are present in same region but not necessary to have same ecological niche are called sympatric species.

36. Ecological succession

The term ecological succession was first given by Hult 1885. Communities keep on changing, *i.e.*, never stable and this definite sequence of communities in the same place over a period of time is called ecological succession or succession. In succession first community is pioneer or first seral stage and the last community is called climax community or last seral stage.

All the seral stages constitute a sere and name of the sere depends upon the substrate where succession begins, *e.g.*, **xerosere**, *i.e.*, succession beginning in dry condition and **hydrosere**, *i.e.*, succession beginning in water.

- In all types of seres, climax community is always **mesophytic.**

37. Pollution

Undesirable change in physical, chemical and biological properties of air, water and soil which directly or indirectly affect organisms is called pollution.

38. Plume

Visible smoke coming out of chimneys is called plume.

39. Flu gas

The gaseous mixture coming out of chimneys is called flu gas.

40. Atmosphere

The gaseous cover over the earth surface is called atmosphere.

ECOLOGICAL FACTORS

Any external thing, substance or condition which has effect on living organism is called ecological factor or factor and totality of all these factors constitute environmental complex or environment.

There are four major types of factors:

(A) Climatic factors : These are related to climate like, (a) Light (b) Temperature (c) Humidity (d) Precipitation (e) Wind (f) Atmosphere (g) Fire.

(B) Topographic factors : These are related with physical geography of earth and are also called **physiographic factors,** *e.g.*, altitude, direction of mountain and valleys, etc.

(C) Edaphic factors or Soil factors : These factors affect through soil.

(D) Biotic factors or Living factors : Living organisms have effect on other living organisms and these constitute biotic factors.

- According to another classification ecological factors are divided into two types:

1. Direct factors : These have direct effect on organisms, *e.g.*, light, temperature, humidity of air, soil air, soil water, soil nutrients, etc.

2. Indirect factors : These affect the organisms indirectly, *i.e.*, by producing change on direct factors, *e.g.*, wind, all topographic factors, soil structure, soil organisms, fire, etc.

All these factors collectively affect the life of organisms.

(A) Climatic factors

(a) Light

Light is important ecological factor as it affects different physiological processes of plants, *e.g.*, photosynthesis, transpiration, movements, flowering, seed germination, etc.

- Main source of light is sunlight and radiant energy of sunlight is converted into different forms of energy on earth. Visible part of the light, *i.e.*, 380–760 nm or 3800–7600 Å is mainly utilized by plants.
- Out of the total sunlight, 12% is reflected back, 5% is transmitted through leaf surfaces, 79% is lost as heat and only 1–4% is utilized in photosynthesis.
- Light intensity is measured by photometer or luxmeter.

Effects of light

(i) Formation of chlorophyll : Almost all the plants require light for chlorophyll formation except seedlings of conifers, young leaves of ferns, few algae and some mosses.

(ii) Effect on stomatal movements : Most of the plants have **photo-active stomata** which open in light and close during night. As stomatal opening and closing is affected by light, hence transpiration process is also influenced by light as stomata are the main avenues for transpiration.

(iii) Effect of light on growth and development : Different plants have different light requirements and hence plants are divided into two main types on the basis of light requirement for growth and development.

(a) Heliophytes or Photophillous or Sun loving plants: These grow in high light conditions, *e.g.*, sunflower.

(b) Sciophytes or Heliophobous or Photophobous or Shade loving plants : These grow in poor light intensity, *e.g.*, *Abies*, *Picea* and *Taxus*, etc.

- There are certain heliophytes which grow best in sun light conditions but can grow fairly well in shady conditions also, are called **facultative sciophytes.**
- Similarly, there are some sciophytes which although grow best in shade but can grow fairly well in sunny conditions also, are called **facultative heliophytes.**
- Heliophytes develop some adaptations for survival in high light intensity. The main differences between heliophytes and sciophytes are as follows:

	Heliophytes	Sciophytes
1.	These have vertically oriented leaves.	Horizontal leaves
2.	Short internodes on stem.	Long internodes
3.	These are profusely branched.	Less branched
4.	Leaves are narrow, small and thick	Large and thin
5.	Stem is thick woody with well developed mechanical and conducting tissue.	Stem is soft and less differentiated into mechanical and conducting tissue.
6.	Leaves have lesser chloroplasts which are smaller in size.	Chloroplasts are more and larger.
7.	Palisade parenchyma is well developed in leaves.	Spongy parenchyma or loosely arranged mesophyll tissue is well developed in leaves.
8.	More resistant to heat and cold.	Less resistant
9.	High root shoot ratio	Comparatively low root shoot ratio.
10.	High osmotic pressure	Comparatively less.
11.	More flowering and fruiting tendency	Poor flowering and fruiting tendency.

(iv) Effect of light on distribution of plants : As light conditions are different in different parts of the earth hence vegetation types are also different at different portions, *i.e.*, at poles, equator, etc.

- In deep water bodies, light reaches only upto 50 m and hence the plants are present only upto this depth. The plants found at maximum depth under water are **red algae** (rhodophyceae) followed by **brown algae** (phaeophyceae).

(v) Effect of light on flowering : Different plants require different periods of light for flowering which is known as photoperiod and the response of the plant to photoperiod in terms of flowering is called **photoperiodism.**

On the basis of photoperiod, the plants are of different types, *i.e.*, **short day plants** (*e.g.*, *Xanthium*, Soybean, etc.), **long day plants**, *e.g.*, *Hyocyamus* (henbane) and **day neutral plants**, *e.g.*, tomato, etc.

(b) Temperature

Temperature is also an important direct ecological factor.

- Temperature is measured with the help of thermometer and temperature under water at desired depth is measured with the help of thermistor.

Important effects of temperature are:

(i) **Effect on metabolic activities :** As different metabolic activities of plants are controlled by different enzymes which are affected by temperature and hence these metabolic activities are affected by temperature, *e.g.*, photosynthesis, respiration, etc.

(ii) **Effect on reproduction (flowering) :** Temperature is also an important factor affecting flowering in plants. Low temperature treatment (0–6°C), *i.e.*, vernalization or springification is responsible for enhancing flowering in plants.

(iii) **Effect on growth and development :** Growth and development are adversely affected by very low and high temperature.

- **Low temperature injury** in plants may be in either of the following three forms:

(a) **Desiccation :** Under low temperature conditions, desiccation of organs and cells occurs due to more transpiration and lower absorption rate.

(b) **Chilling ;** Low temperature injury in the plants of hot climate (tropical plants) is called chilling.

(c) **Freezing :** Low temperature injury in the plants of cold climate (temperate plants).

- Freezing may be **intercellular**, *i.e.*, ice formation occurs in intercellular spaces at low temperature or **intracellular**, *i.e.*, at extremely low temperature, ice formation occurs in intracellular spaces (inside the cells) and this ultimately leads to the death of cells and hence plants.
- **High temperature injury** or heat injury–Very high temperature adversely affects different physiological processes which ultimately lead to the death of plant.

Protoplasmic hardening :

Sometimes young plants are exposed to low temperature under poor water supply for short periods of time. This results in increase in resistance of plants to cold and drought conditions and this protoplasmic characteristic is called protoplasmic hardening.

- **Altitude** (height above the sea level) and **latitude** (distance from equator) have effect on temperature which in turn affect type of vegetation. Effect of altitude and latitude are almost same on temperature and vegetation. The types of vegetation from sea level to increasing altitudes are **tropical or evergreen forest, xerophytic plants** or **deserts, deciduous vegetation, conifers** (*e.g.*, *Pinus*, *Taxus*, *Cedrus*, *Picea*, etc.), **alpine vegetation** (*Rhododendrons* and *Juniperus*) which is found at 3600 m or 12,000 ft above sea level and **tundra region** where small grasses like *Saxifraga*, *Primula* and lichens, etc., occur.

Almost similar change in vegetation occurs with latitude, *i.e.*, from equator to poles.

- Based on temperature, the vegetation of the whole world is divided into four major groups :

(i) **Megatherms :** The plants growing in high temperature throughout the year, *e.g.*, tropical rain forests.

(ii) **Mesotherms :** The plants growing in alternate high and low temperature, *e.g.*, deciduous vegetation.

(iii) **Microtherms :** Plants growing in low temperature, *e.g.*, coniferous vegetation.

(iv) **Hekistotherms :** Plants growing in very low temperature, *e.g.*, alpine vegetation.

(c) Atmospheric humidity

Moisture in form of invisible vapours in atmosphere is called humidity.

Atmospheric humidity is generally expressed in terms of **relative humidity** (R.H.) which is defined as, "amount of vapours in atmosphere as the percentage of total amount which the air or atmosphere can hold at the existing temperature."

R.H. is influenced by environmental conditions like solar radiation, temperature, wind, etc. If temperature is high, R.H. is low and if temperature is low, R.H. is high.

○ R.H. is measured with the help of **psychrometer** or **paper strip hydrometer** or **thermo-hygrograph.**

The effect of humidity is similar to that of low light intensity. Certain plants which grow in high relative humidity are called **hygrophytes**, *e.g.*, lichens, mosses and orchids.

(d) Precipitation

The source of soil water is precipitation. There is exchange of water between earth surface and atmosphere which constitutes water cycle or hydrological cycle. The processes responsible for hydrological cycle are precipitation and trans-evaporation. Precipitation is the result of gravitational pull on the water vapours present in the atmosphere. The different forms of precipitation are **drizzle** (minute drops of water floating in air), **rain** (large drops of water), **snow** (water in solid form), **sleet** (ice in minute granular form), **hales** (large balls of ice) and **dew and frost** (due to condensation of water vapours in contact with solid objects).

- Rainfall is the chief source of precipitation. Out of the total rainfall, 45% is run away or runoff water which flows to rivers and oceans, 35% is evaporated and rest 20% is absorbed by the ground.
- Amount and timings of rainfall determine the type of vegetation of an area, *e.g.*,

(i) If no rainfall or scanty rainfall throughout the year then **xerophytic vegetation** or deserts occur.

(ii) If more rainfall in summer and less in winter, then grasslands will develop.

(iii) If more rainfall in winter and less in summer, then thick, dwarf shrubs with leathery leaves, *i.e.*, **sclerophyllous** vegetation occurs.

(iv) If rainfall occurs throughout the year then evergreen forests, *e.g.*, **tropical rain forests** occur.

(e) Wind

Wind is defined as air in motion. Generally wind speed is upto 50 km/hour. If the speed is more than this then such winds are called **gales** (60–90 km/hour), **storm** (90–120 km/hour) and **hurricane** (above 120 km/hour).

Wind speed is measured with the help of **anemometer.**

The effects of wind are more conspicuous on sea coasts and mountains. Important effects of wind are:

(i) **Lodging :** Flattening of plants against ground due to wind action is called lodging. This generally occurs in grasses (members of Gramineae).

(ii) **Dwarfness of plants :** High wind velocity leads to desiccation which leads to loss of turgidity of cells, reduction in cell size and hence dwarfism.

(iii) **Uprooting :** The plants are uprooted by high wind velocity and these plants are called **wind falls or wind throws.**

(iv) **Distortion in shape of plants :** Occurs due to development only on one side.

(v) **Abrasions :** The soil particles carried by wind cause abrasions with plants and produce injury or wounds through which infection occurs.

(vi) **Formation of compression wood :** Hard, reddish compressed wood formed on compressed side of the plant due to high wind velocity is called compression wood.

- ○ Row of tall trees are planted at the margins of the field to prevent wind action are called **wind breaks.**
- Some plants called **cushion plants** which have generally crowded branches and cushion like roots are resistant to wind action.

(f) Atmosphere

Gaseous cover over the earth surface is called atmosphere. Earth's atmosphere is about upto height of 300 km, out of which 95% of gases is upto height of 20 km and rest 5% in next 280 km.

- Earth's atmosphere is having a mixture of gases out of which important ones are:

(1) **Nitrogen** — 78·08% (by volume)
(2) **Oxygen** — 20·84% (by volume)
(3) **Argon** — 0.93% (by volume)
(4) **CO_2** — 0.03% (300 ppm)

Earth's atmosphere is divided into four different zones from below to above:

(i) **Troposphere :** First 20 km of earth's atmosphere is called troposphere in which different physical phenomena, *i.e.*, lightening, thundering and cloud formation occur.

Temperature goes on decreasing as we move higher and higher in troposphere and this decrease is 6.5°C in temperature with every km. At the end of trophosphere the temperature is as low as – 60°C.

The extreme limit of troposphere which merges with next zone, *i.e.*, stratosphere is called **tropopause.**

(ii) **Stratosphere :** About 30 km zone over troposphere is called stratosphere.

- ○ Temperature increases in this zone (upto 90°C) due to ozone formation. In this zone under the influence of ultra-violet rays, this ozone layer is formed, which prevents entry of harmful UV-rays to reach the earth surface.

$$\text{Oxides of Nitrogen + Unburnt Hydrocarbons} \xrightarrow{\text{UV-rays}} O_3 \text{ (Ozone) + PAN (Peroxy acetyl nitrate)}$$

The extreme limit of stratosphere which merges with next zone, *i.e.*, mesosphere is called **stratopause.**

(iii) **Mesosphere :** Next 40 km zone above stratosphere is called mesosphere. Last limit of mesosphere is called mesopause.

(iv) **Ionosphere :** Uppermost zone of atmosphere is ionosphere and in this zone all the gases are in ionized form.

(g) Fire

Fire may be man caused or natural and it is basically of three types:

(i) **Surface fire :** Which moves over the surface with speed and also with flames.

(ii) **Ground fire :** Flameless fire in the heaps of organic matter is called ground fire.

(iii) **Crown fire :** Furious fire with high flames which generally occurs in forests leading to considerable rise in temperature (upto 1300°F).

Effects of fire

(i) **Effect on different environmental conditions :** Fire leads to change in different conditions, *e.g.*, light intensity, pH, also on living organisms.

(ii) **Removal of competitions :** Fire reduces the competitions between plants upto some extent by destroying some fire sensitive plants.

(iii) **Direct killing of plants :** Fire directly kills many plants by burning them.

(iv) **Wounds or Injury :** Fire causes scars or wounds on trunks of plants through which infection by bacteria and fungi may occur.

(v) **Growth stimulation :** There are some plants where growth is stimulated by fire, *e.g.*, *Epilobium angustifolium*, *Populus tremuloides*, etc. This stimulation may be in terms of increased seed production as in *Cynodon* (doob grass), *Andropogon* and *Tephrosia*, etc. Similarly, an ascomycetes fungus *Pyronema confluens* and a bryophyte *Marchantia polymorpha* grow well in fire burnt condition.

- ○ Such plants which grow well in fire burnt condition are called **pyrophytes** or **fire loving plants.**

(B) Topographic factors or Physiographic factors

The ecological factors which are connected with physical geography of earth constitute physiographic or topographic factors.

- These factors change different climatic conditions which in turn affect the vegetation and thus the topographic factors are **indirect ecological factors.** Important topographic factors are:

(i) **Altitude :** Height above the sea level (altitude) is an important topographic factor. With increase in altitude, the climatic conditions go on changing and hence type of vegetation also changes (temperature factor).

(ii) **Directions of valleys and mountains :** Mountains deflect the winds and also cause condensation of water vapours leading to precipitation. Thus direction of mountains is an important ecological factor, *e.g.*, outer Himalayas are luxuriant in vegetation by causing condensation of clouds whereas middle and inner Himalayas have poor vegetation because of poor rainfall.

(iii) **Slope steepness :** Steepness of slope affects amount of solar radiation and hence temperature. Secondly soil conditions are also affected due to effect on water conditions. Northern slopes in northern hemisphere are having dense **hygrophyllous vegetation** whereas southern slopes show poor or **xerophytic vegetation** because southern slopes receive right angled sun rays during noon which lead to increase in temperature and hence poor water conditions. The northern slopes on the other hand get oblique sun rays only during morning and evening leading to low temperature and hence good water conditions.

(iv) **Exposure of slopes :** The slopes which are well exposed show different vegetation than the slopes which are less exposed.

(C) Edaphic factors

The factors which affect the plants through soil are called **edaphic factors.** Soil is very important ecological factor as it provides water, minerals or nutrients and support. **Warming** (1909) was the first ecologist who recognised the importance of soil as ecological factor and he divided plants into five different types on the basis of the soil conditions, *i.e.*, **halophytes** (plants growing in salty or saline soil), **oxylophytes** (plants growing in acidic soil), **psammophytes** (plants growing in sandy soil), **chasmophytes** (plants growing in rock crevices) and **lithophytes** (plants growing on rocks).

- Upper part of the earth crust in which plants are rooted is called soil.
- Soil formation is very slow process and **one inch** of soil formation takes **500–1000 yrs.**

Soil is having not only mineral particles but some other components like organic matter or humus, soil air, soil water and soil organisms like bacteria, fungi, algae, actinomycetes, annelids and molluscs, etc. Thus soil is called **soil complex.**

- Good soil is having following components:

(i) Mineral particles about 40%
(ii) Organic matter or humus about 10%.
(iii) Soil air 25%.
(iv) Soil water 25%
(v) Soil microflora and fauna.

Soil formation is completed in two steps:

(a) **Weathering :** Breaking down of rocks is called weathering and weathering is by **physical** (water, wind, gravity, glaciers, etc.) and **chemical** (oxidation-reduction reactions, hydrolysis, hydration, chelation, etc.) methods.

(b) **Pedogenesis :** Actual soil formation or development is called pedogenesis and it is mainly by activity of micro-organisms or soil organisms.

- The branch dealing with the study of soils is called **pedology.**

Soil profile

Nature and sequence of different layers or horizons in vertical section of soil is called soil profile.

Different horizons or layers of soil from above to below are as follows:

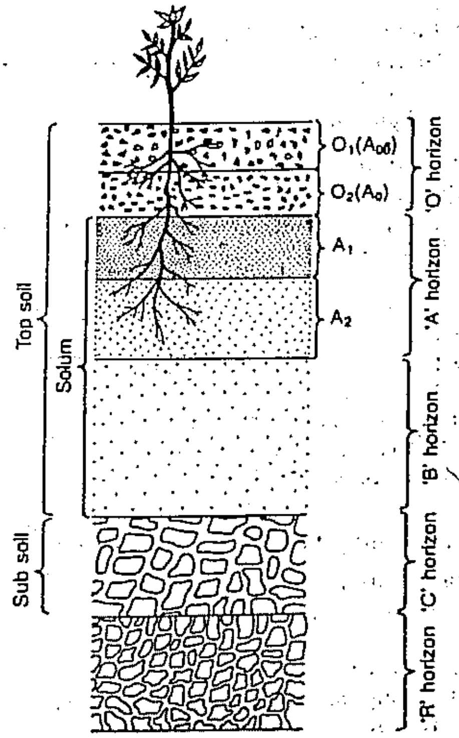


Fig. 26.1. Soil profile showing different horizons

(i) **A_{00} horizon :** Having undecomposed organic matter (litter).

(ii) **A_0 horizon :** Having partially decomposed organic matter (duff).

- Both these horizons constitute **O horizon.**

(iii) **A_1 horizon :** Having fully decomposed organic matter (humus).

(iv) A_2 horizon : Having mineral particles along with little humus.

- Both A_1 and A_2 collectively constitute A horizon.

(v) B horizon : Having only mineral particles.

- All these horizons constitute **top soil** which is 15–20 cm thick.

(vi) C horizon : Having incompletely broken mineral particles.

(vii) R horizon : Having unbroken rocks.

- C and R horizons collectively constitute sub-soil.

Types of soil on the basis of mode of formation

On this basis, soils are basically of two types:

(i) Residual soil : In this type of soil, place of weathering and pedogenesis is the same.

(ii) Transported soil : In which pedogenesis occurs at a place different from place of weathering. Based on the transporting agency, the transported soils are of following types:

(a) Alluvial soil : If weathered particles are transported by water.

(b) Colluvial soil : If transporting agency is gravity.

(c) Glacial soil : If transporting agency is glaciers, *i.e.*, large ice pieces.

(d) Eolian soil: If transporting agency is wind.

Components of soil complex and their characteristics

(i) Mineral particles : These are the chief components of soil complex and are formed by weathering of rocks. Depending upon size of mineral particles, soils are of following types:

(a) Clay : If particle size is **less than 0.002** mm.

(b) Silt : If particle size is **0.002–0.02 mm.**

(c) Fine sand : If the particles size is **0.02–0.2 mm.**

(d) Coarse sand : 0.2–2 mm.

(e) Gravel or Stone : More than 2 mm.

Thus the correct sequence according to increasing particle size is :

Clay < Silt < Fine sand < Coarse sand < Gravel

Soil texture : The proportion of particles of different sizes determine the soil texture and on this basis soils are of following types:

(a) Clayey : 85% clay + 15% sand or silt or both.

(b) Loamy sand : 70% clay + 30% sand or silt or both.

(c) Loamy : 50% clay + 50% sand or silt or both.

○ Loamy soil is best for plant growth.

(d) Sandy soil : 85% sand + 15% clay.

Soil texture determines soil air, soil water and root penetration properties.

(ii) Soil air : Interparticle spaces are occupied by soil air, besides some liquids.

- The gases present in interparticle spaces constitute soil atmosphere and the gases present in the soil atmosphere are the same as present in earth's atmosphere, *i.e.*, $N_2 + Ar \rightarrow 79\%$ and rest are $O_2 + CO_2$. But CO_2 concentration is slightly more in soil atmosphere (upto 0.5–1%) and O_2 level is less, *i.e.*, about 20%.
- Sandy soils are well aerated whereas clayey soils are poorly aerated.
- Poor aeration of soil causes poor root and root hair development and hence has adverse effect on growth of plants.

(iii) Soil water : Chief source of water to soil is rainfall. Size of the mineral particles affects the amount of water retained by the soil.

○ Sandy soils are well drained and thus are **physically dry soils**, whereas in clayey soils **water logging** occurs and thus poorly aerated.

○ In some soils although abundant water is present but plants are unable to absorb water due to :

(a) High salt concentration, *i.e.*, saline soil : Plants growing in saline soil are called **halophytes.**

(b) Very low temperature or Cold soil : Plants growing in cold soil are called **psychrophytes** or **cryophytes.**

(c) High acidity : Plants growing in high acidic soils are called **oxylophytes.**

In all these above conditions, water is not absorbed inspite of its presence. Such soils are called physiologically dry soil and this type of dryness is called **physiological dryness.**

Forms of soil water

(1) Hygroscopic water : A thin layer of water attached tightly to soil particles due to forces of cohesion or adhesion. This water is **non-available** to plants, *i.e.*, cannot be absorbed by plants.

(2) Gravitational water : Some water goes into deep soil horizons due to force of gravity which is out of the reach of the roots of plants. This water is called gravitational water and is **non-available** to plants again.

(3) Capillary water : Inter-particle spaces or pore spaces act as minute capillaries and some amount of water is present in these capillaries due to surface tension. This water is called capillary water and it is the only form of soil water which is absorbed by the roots of the plants, *i.e.*, **available water.**

(4) Combined water : Some amount of water is present as hydroxide of iron, aluminium, silicon, etc., which is called combined water and again is **non-available** water.

(5) Water vapours : Some water is present in the form of vapours.

- Total amount of water present in soil is called **holard.**
- Water available to the plants is called **chresard.**
- Water non-available to plants is called **echard.**

Field capacity : Amount of water present in soil after complete drainage of gravitational water, is called field capacity.

Field capacity = Holard – Gravitational water

Water holding capacity or Storage capacity :

Field capacity – Hygroscopic water = Water holding capacity

Wilting coefficient or Permanent wilting percentage : Percentage of water left in soil when plants growing in it show signs of permanent wilting. *i.e.*, they do not regain their turgidity without adding extra amount of water to soil, is called wilting coefficient.

$$\text{Wilting coefficient} = \frac{\text{Water holding capacity}}{2.9}$$

- Soil moisture is expressed in terms of pF.

pF = 0 in fully saturated soils and pF = 4·2 at permanent wilting percentage.

- Amount of water in soil is measured with the help of **tensiometer.**
- Soil water contains different nutrient solutes dissolved in it, *e.g.*, carbonates, sulphates, nitrates, chlorides, etc. of calcium, magnesium, potassium, etc.
- Soils with optimum nutrients are called **eutrophic soils** and soils having sub-optimum nutrients are known as **oligotrophic soils.**
- pH of natural soils is 3–8.4, however in extreme alkaline soils, pH may be upto 10–10.5 and in extreme acidic soils it may reach upto 2.
- International term solonetz is given to black alkaline soil having excess of Na and K carbonates. NaOH and KOH formed in these soils have corosive action on humus and hence turn black. Another term **solonchak** is given to white alkaline soil having excess of carbonates other than Na and K.
- Soils having excess of calcium carbonate are called **calcarious soils.**
- Alkaline soils can be corrected by adding gypsum ($CaSO_4$) and heavy irrigation whereas acidic soil can be corrected by adding lime $Ca(OH)_2$.
- pH of fertile soil is **6–7.** pH of soil has effect on microbial activity.
- **Calcicoles** are the plants which grow in high pH, *i.e.*, 6.5 or more whereas **calcifuges** are the plants which grow in low pH, *i.e.*, 3.5 or less.

(iv) Organic matter or Humus : The main source of mineral return to the soil is organic matter or humus. Humus is having high water holding capacity and makes the soil porous, *i.e.*, aerated. It is due to humus that water percolates through the soil slowly.

(A good soil is that which allows percolation of water slowly through it).

Humus formation is called **humification.**

$$\text{Litter} \longrightarrow \text{Duff} \longrightarrow \text{Humus}$$

{Freshly fallen organic matter} {Partially decomposed organic matter} {Fully decomposed organic matter}

Humus contains humic complexes or phenolic complexes, soluble proteins, soluble sugars, amino acids and organic acids.

Eolian soil

Types of humus : It is of two types:

(a) Mor humus or Raw humus or Coarse textured humus

It is the characteristic of podsol (soil formed in cold humid regions in low pH or high acidity.)

(b) Mull humus or Fine textured humus

(v) Soil micro-organisms : Each soil has its characteristic microflora and fauna, *e.g.*, bacteria, actinomycetes, blue green algae, fungi, molluscs, annelids, rotifers, etc.

- These micro-organisms maintain fertility of soil (when no fertilizers are added to soil then activity of micro-organisms is responsible for fertility of soil). The important roles of micro-organisms are as follows:

(a) Nitrogen fixation : Symbiotic bacteria, *Rhizobium* in root nodules of legumes and some non-legumes, *Azotobacter, Clostridium* (bacteria) and blue green algae like *Nostoc, Anabaena, Oscillatoria*, etc., fix atmospheric nitrogen and thus increase the fertility of soil.

(b) Soil formation : Organisms like annelids make the soil porous by burrowing and thus make the soil well aerated and hence these are called **natural farmers.** Blue green algae secrete mucilage which make the soil good by aggregating the soil particles.

(c) Antibiosis : Some soil micro-organisms secrete some chemical substances which kill other harmful micro-organisms. Such substances thus secreted are called antibiotics and this phenomenon is known as **antibiosis.**

(d) Stimulation of root growth : In the rhizosphere (soil zone around the roots), there are present microbes which secret, sugars, hormones like IAA, etc., which stimulate growth of roots.

(e) Decomposition of organic substances : Soil micro-organisms like bacteria, fungi, actinomycetes, etc. decompose dead organic matter into simple inorganic substances and thus continue biogeochemical or material cycles.

Some special types of soil on basis of climatic conditions

(i) Laterite soils or Latosols : This type of soil is found in warm humid region. The colour of this soil is **reddish** brown and there is excess of iron and aluminium in surface horizons. Leaching of silicic acid occurs to lower horizons in these soils. Such soils are not so fertile, *e.g.*, red soils of Orissa are of this type.

(ii) Podsols : Such soils are found in cool humid regions and is ash **coloured.** This type of soil is mainly found below conifers whose leaves are having low calcium contents and thus maintain acidic conditions. During rainfall these acids leach away Fe, Al and carbonates, etc., to deeper horizons and surface remains ash coloured. Such soils are also less fertile.

(iii) Gleys : Such soils are found below ice where peat deposition occurs, *e.g.*, soils in tundra region.

- Black cotton soils of Maharashtra are commonly known as **regur.**

(D) Biotic factors

Living organisms living together influence each other's life and these living organisms constitute biotic factors. In these biotic interactions both the organisms may be benefitted or one is benefitted or one is benefitted while another is harmed or both are harmed.

These biotic interactions are of two main types :

(a) **Positive interactions :** Where both the organisms or one organism is benefitted.

(b) **Negative interactions :** Where both the organisms or one organism is harmed.

(a) Positive interactions

The main types of positive interactions are:

1. **Mutualism or Symbiosis :** Here both the organisms in association are mutually benefitted and further this association is **obligatory,** *i.e.*, necessary for existence of both organisms. Important examples of symbiosis are:

(i) Dispersal of fruits and seeds by living organisms.

(ii) Pollination by insects, animals, etc.

(iii) **Symbiotic nitrogen fixation :** In the root nodules of legumes and some non-legumes, *Rhizobium* bacteria (symbiotic) are present which obtain food and shelter from parent plant and in turn fix atmospheric nitrogen.

(iv) **Mycorrhiza or Mycorrhizal association :** Association between roots of higher plants and fungal hyphae is called mycorrhiza. It is of two types:

(a) **Ectotrophic or Ectophytic mycorrhiza :** In this association fungal hyphae are on surface of roots, *e.g.*, in *Pinus*.

(b) **Endotrophic or Endophytic mycorrhiza :** Here fungal hyphae are inside the root tissue, *e.g.*, in orchids.

- *Rhizoctonia* is the most common fungus associated in this association.

(v) **Lichens :** These are composite plants in which algal partner and fungal partner are mutually associated.

(vi) **Myrmecophilly :** Association between ants and higher plants is called myrmecophilly, *e.g.*, jamun, litchi, mango, etc., where ants live. The ants get their food from the plants and in turn act as body-guards.

(vii) **Zoochlorellae :** Unicellular green alga *Chlorella vulgaris* lives in gastrodermal cavity of *Hydra*. The alga gives food and oxygen to *Hydra* and *Hydra* in turn gives shelter and nitrogenous substances to alga.

- The term symbiosis or mutualism was given by **DeBary.**

2. **Protocooperation :** In this association the two organisms are mutually benefitted by each other. But the association is **non-obligatory,** *i.e.*, not necessary for their existence, *e.g.*, association between hermit crab and sea anemone. Hermit crab takes sea anemone on his back to other feeding zone and in turn gets protection from his enemies.

3. **Commensalism :** In this association only one organism is benefited and neither is harmed. There is no physiological exchange between these organisms, *e.g.*,

(i) **Epiphytes or Aerophytes :** These are vascular plants which are **not rooted** in soil and grow upon other plants for support (but not food), *e.g.*, some orchids like *Vanda, Dendrobium*, etc., members of family Bromeliaceae (bromeliads), *Dischidia* (here a pitcher like structure is present for accumulation of water), *Asplenium* (bird's nest epiphyte), etc.

○ Epiphytes are common in tropical rain forests.

- Three types of roots are present in epiphytes:

(a) **Clinging roots** for attachment.

(b) **Absorptive roots** for absorption of nutrients and minerals from organic matter accumulated in crevices of bark.

(c) **Aerial roots :** These roots possess a special tissue having thickenings called velamen, which help in absorption of moisture from atmosphere.

(ii) **Lianas :** These are vascular plants **rooted in soil** and get support of other plants or objects for their erectness.

- *Lianas* are common in tropical rain forests. *e.g.*, *Bauhinia, Ficus, Tinospora*, etc.

○ Most common lianas in Indian tropical forests is *Bauhinia vauhilii.*

(iii) **Rhizosphere, Rhizoplane, Phyllosphere and Phylloplane :** Soil zone around the roots in which a large number of microbes are present due to secretion of sugars, etc., by roots is called **rhizosphere.** The root proper surface is called **rhizoplane.** Similarly air zone around leaves having good population of microbes due to secretion of volatile substance by leaves is called **phyllosphere** and leaf proper surface is called **phylloplane.**

- Some workers consider these as example of mutualism.

(b) Negative interactions

Here one or both organism in association are harmed. Important examples of these interactions are :

1. **Parasitism :** A parasite is an organism which lives in constant association with host and gets its food directly or indirectly without killing the host. This phenomenon is called parasitism. In plants four major types of parasites are present:

(i) **Total stem parasite,** *e.g.*, *Cuscuta.*

(ii) **Total root parasite,** *e.g.*, *Rafflesia, Orobanche, Epifagus, Conopholis*, etc.

(iii) **Partial stem parasite,** *e.g.*, *Viscum* and *Loranthus.*

(iv) **Partial root parasites,** *e.g.*, *Santalum* and *Thesium.*

2. **Predation :** A predator is an organism which gets its food from the host after killing it. It does not live in constant association with host. This phenomenon is called predation. Important examples of predation are:

(i) **Grazing and browsing**

(ii) **Carnivorous or Insectivorous plants :** These plants grow in marshy conditions where there is lack of nitrogen, so in order to fulfil their nitrogen requirement, they catch small insects by some special adaptations in them. They secrete proteolytic enzymes which break down protein into simple nitrogenous substances which in turn are secreted by these plants. *e.g.*, *Nepenthes* (pitcher plant), *Utricularia* (bladder wort), *Drosera* (sun dew plant), *Darlingtonia, Cephalotus, Aldovanda, Sarracenia*, etc.

(iii) Predaceous fungi : In soil there are present some fungi like *Dactylella, Dactylaria, Arthobotrys* and *Zoophagus*, etc., which are called predaceous fungi. These have rings in their mycelium which act as nooses. The annelids or other organisms which enter these rings are killed and then these fungi send haustoria inside these killed organisms to obtain their food.

3. Competition : It is a type of cold war in which both the organisms in association are harmed. Competition is for basic necessities of life. Competition may be interspecific or intraspecific but **intraspecific competition is more severe** because organisms of same species have similar basic requirements.

4. Amensalism : This is a type of association in which one organism in association is harmed and second is not affected. Amensalism is of two types:

(i) Antibiosis : Some micro-organisms secrete certain chemical substances which kill or inhibit other micro-organisms. These substances are called antibiotics and phenomenon is called antibiosis.

(ii) Allelopathy : Some higher plants also secrete certain poisonous substances which inhibit the growth of other plants. This phenomenon is called allelopathy, *e.g.*, roots of carrot grass or congress grass (*Parthenium argentatum*), which is **most troublesome terrestrial weed** in India secrete **trans-cinnamic acid** which checks the growth of other plants.

Man as biotic factor : Man is always most important biotic factor. He changes the environment by his activities regularly, *e.g.*, by excessive cutting of trees, fire, domestication of plants and animals, by causing different types of pollution, etc.

ECOSYSTEM

Term ecosystem was first of all given by **A.G. Tansley (1935)**, he defined it as, "system arising out of interactions between living and non-living components of environment". (*Eco* – environment + *System* – interacting, interdependent complex).

In any ecosystem, communities or living organisms interact with their physical environment in such a way that there is a well defined flow of energy forming clear trophic (food) levels and material cycles within this system.

- Ecosystem is normally an **open system** because there is a continuous and variable entry and loss of energy and materials.
- Ecosystem is known by different terms, *i.e.*, **biogeocoenosis or geobiocoenosis or microcosm or ecosom or holocoen or biosystem or bioinert body**, etc., the whole earth can be called **biosphere or ecosphere.**

Types of ecosystem

It is mainly of two types:

(A) Natural ecosystems : Which are governed by natural conditions or nature without much interference of man, these are further of two types:

(1) Terrestrial natural ecosystem : *e.g.*, forest ecosystem, grassland ecosystem and desert ecosystem, etc.

(2) Aquatic natural ecosystem : It is further of two types:

(i) Fresh water ecosystem :

(a) Lentic (stationary water) : *e.g.*, pond ecosystem, pool ecosystem, ditch ecosystem.

(b) Lotic (running water) : *e.g.*, river ecosystem, stream ecosystem, spring ecosystem.

- Study of fresh water ecosystems is called **limnology.**

(ii) Marine ecosystem : *e.g.*, ocean (deep water), sea (shallow water)

(B) Artificial ecosystems or Man engineered ecosystems : Which are governed by man, *e.g.*, crop land ecosystem, aquarium, etc.

Structure and function of ecosystem

In structure of ecosystem we include—

(a) Biotic components or Biotic communities or Living components.

(b) Abiotic components or organic and inorganic substances or non-living components.

(c) Climatic conditions.

In function we study—

(a) Rate of energy flow in ecosystem.

(b) Material cycles or biogeochemical cycles.

Structure of ecosystem

Mainly two types of components constitute the structure of ecosystem:

(A) Abiotic components or Non living components:

These include inorganic substances or minerals (standing state or standing quality), organic substances and different climatic conditions like temperature, pH, light, etc.

(B) Biotic components or Living components:

(i) Autotrophs or Producers : Which have capacity to manufacture their own food or which can fix radiant energy of sun into chemical energy, *e.g.*, green plants and photosynthetic bacteria.

(ii) Heterotrophs or Consumers : Which are unable to manufacture their own food and depend upon other organisms for their food. These are of following types:

(a) Primary consumers or Herbivores or Consumers of first order : These depend upon producers or green plants for their food.

(b) Secondary consumers or Carnivores or Consumers of second order : These live upon herbivores.

(c) Top consumers or Top carnivores : Which live upon secondary consumers.

(iii) Decomposers or Microconsumers : These decompose dead organic substances of producers and consumers into simple substances and thus continue material cycles, *e.g.*, bacteria, fungi, actinomycetes, etc.

Let us take the examples of some ecosystems.

Pond ecosystem

It is lentic fresh water natural ecosystem.

(A) Abiotic components : Water of the pond, different conditions like temperature, light intensity, pH of water, different inorganic substances like CO_2, O_2, Ca, K and Mg, etc. and organic substances like proteins, amino acid, humic acid, etc.

(B) Biotic components :

(i) Autotrophs or Producers : These include macrophytes (large plants), *e.g.*, *Typha, Trapa, Hydrilla, Wolfia, Eichhornia, Ranunculus*, etc., and phytoplanktons (floating or suspended small plants) like *Volvox, Cladophora, Zygnema, Eudorina*, diatoms and photosynthetic bacteria, etc.

(ii) Heterotrophs or consumers :

(a) Primary consumers or Herbivores : Small fish, insect larvae, beetles, molluscs, rotifers, etc.

(b) Secondary consumers : Fish, insects, snakes, etc.

(c) Tertiary consumers : Large game fish, etc.

(iii) Decomposers or Microconsumers : Bacteria, actinomycetes, some fungi like *Saprolegnia, Curvularia, Pythium*, etc.

Forest ecosystem

It is terrestrial natural ecosystem

- Forests occupy 40% of land in world. In India forests occupy only 22·8% of land area.

(A) Abiotic components : Minerals, organic substances, inorganic substances, climatic conditions like light, temperature, etc.

(B) Biotic components :

(i) Producers : Different trees of the forest and shrubs as well as ground flora.

(ii) Consumers :

(a) Primary consumers : Ants, bugs, leaf hoppers, birds, some large animals like deer, neel gai, flying foxes, fruit bats, elephants, etc.

(b) Secondary consumers : Snakes, lizzard, mangoose, some birds, etc.

(c) Tertiary consumers : Lions, tigers, etc.

(iii) Decomposers : Bacteria, fungi, actinomycetes, etc.

Grass-land ecosystem

Grasslands occupy only 19% of the total earth surface. It is terrestrial natural ecosystem.

- Temperate grasslands of **North America** are known as **Prairies.**
- Temperate grasslands of **Asia** are called **Steppes.**
- Tropical grasslands of **South America** are known as **Pampas.**
- Tropical grasslands of **Asia** including **India** are known as **Savannah** (type of grasslands in which trees and shrubs are present at wide intervals).

Desert ecosystem

It is terrestrial natural ecosystem. Deserts occupy 17% of total land in the world. Deserts are present in regions where annual rainfall is below 25 cm.

Oceans

Oceans occupy 70–75% of total earth surface.

Ecological pyramids or Food pyramids

Trophic structure of ecosystem is a type of producer–consumer arrangement, in which each food level is called trophic level and the graphical representation of trophic structure of ecosystem constitutes ecological pyramids or food pyramids where **producers occupy base of the pyramid and top consumers occupy apex of the pyramids.** The concept of ecological pyramids was developed by **Elton** (1927).

The ecological pyramids are of three types :

(A) Pyramids of number : In which number of individuals at each trophic level is shown in pyramid.

(B) Pyramids of biomass : Where biomass of each trophic level is shown in pyramid.

(C) Pyramids of energy : Where energy content or productivity of different trophic levels is shown in pyramid.

- Pyramids of number and biomass may be upright or inverted, depending upon type of ecosystem but **pyramid of energy is always upright** because energy of the producers is always more than primary consumers and so on, *i.e.*, energy goes on decreasing.

(A) Pyramids of number

These may be upright, inverted or intermediate type, *e.g.*, in grassland ecosystem, the pyramid of number is upright because number of producers (grasses) is maximum and the number goes on decreasing with every trophic level, *i.e.*, top consumers are minimum in number. (Fig. 26.2)

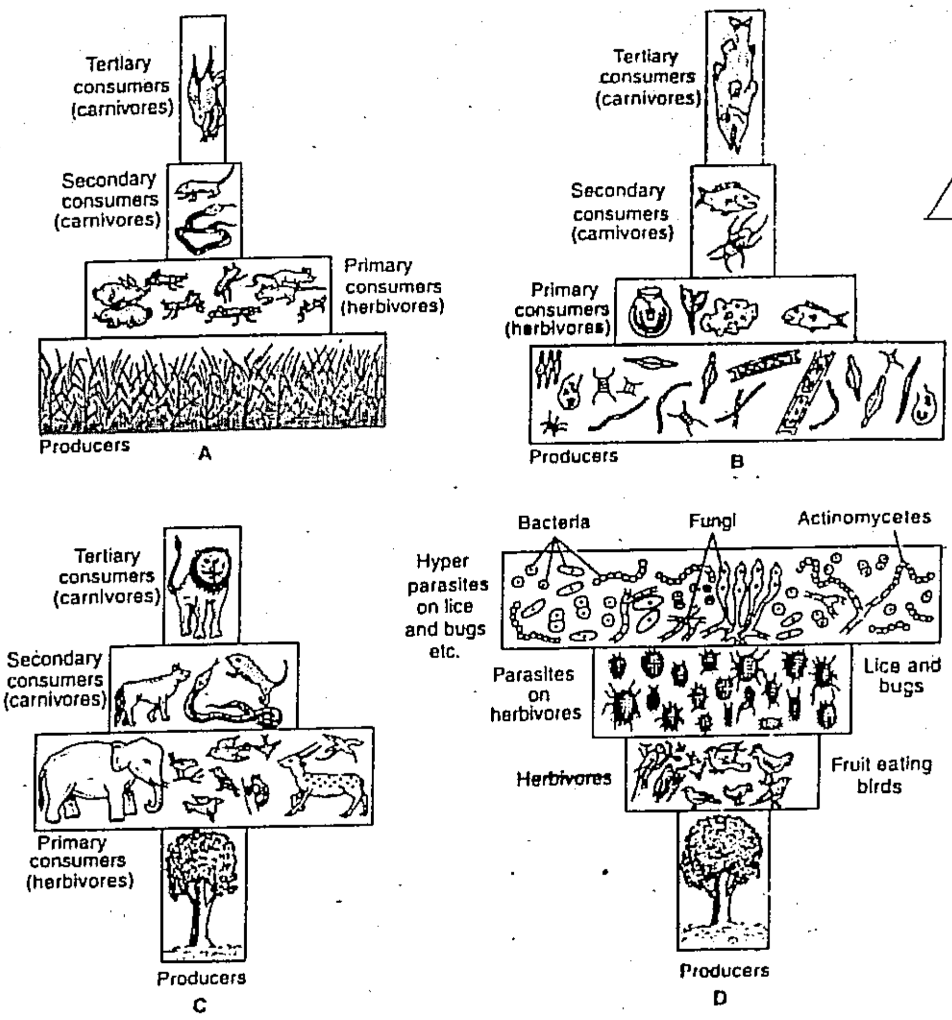
Similarly, the pyramid of number in pond ecosystem is also upright. In forest ecosystem the pyramid of number is intermediate. Here the number of primary consumers is more than producers as well as top consumers.

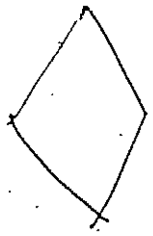
In parasitic food chain the pyramid of number is inverted. Here the number of producers is minimum and top consumers or hyperparasites are maximum.

- (Number of producers per unit area is more in pond ecosystem than in grassland ecosystem.)

(B) Pyramids of biomass

These are more fundamental and may be upright or inverted, *e.g.*, in grassland ecosystem, upright pyramid of biomass is present because biomass of producers is maximum and of top consumers is minimum. Similarly in forest ecosystem upright pyramid of biomass is present whereas in pond ecosystem these are of inverted type as biomass of


Tertiary
consumers
(carnivores)
Secondary
consumers
(carnivores)
Primary
consumers
(herbivores)
Producers
A
Tertiary
consumers
(carnivores)
Secondary
consumers
(carnivores)
Primary
consumers
(herbivores)
Producers
B
Tertiary
consumers
(carnivores)
Secondary
consumers
(carnivores)
Primary
consumers
(herbivores)
Producers
C
Bacteria
Fungi
Actinomycetes
Hyper
parasites
on lice
and bugs
etc.
Parasites
on
herbivores
Lice and
bugs
Herbivores
Fruit eating
birds
Producers
D



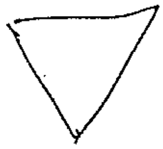


Fig. 26.2. Pyramids of numbers in different ecosystems A. Grassland ecosystem B. Pond ecosystem C. Forest ecosystem D. Parasitic food-chain

producers is minimum and of top consumers is maximum. (Fig. 26.3)

(C) Pyramids of energy

These are most fundamental and they indicate overall nature of ecosystem.

- Pyramid of energy is always upright in all types of ecosystem as energy goes on decreasing with each and every trophic level.

Food-chains

The process of transfer of energy from producers through a series of organisms, *i.e.*, from primary consumers to secondary consumers and from secondary consumers to tertiary consumers by process of eating and being eaten constitute a food-chain, *e.g.*, in grassland ecosystem. (Fig. 26.4)

$$\text{Grass} \xrightarrow{\text{Eaten by}} \text{Rabbit} \xrightarrow{\text{Eaten by}} \text{Hawk}$$

This sequence of eating and being eaten is called food-chain. In nature two major types of food-chains are present:

(a) Grazing food-chain

(b) Detritious food-chain

(a) Grazing food-chain : This type of food-chain begins with green plants which are eaten by herbivores which in turn are eaten by carnivores.

- The ecosystem having this type of food-chains are directly dependent on solar radiation.

Grazing food-chains are more common, *e.g.*,

Grass ⟶ Grasshopper ⟶ Lizard ⟶ Hawk

(b) Detritious food-chain : This type of food-chain starts from dead organic matter acted upon by decomposers, which in turn are eaten by detrivores consumers which are eaten by top consumers.

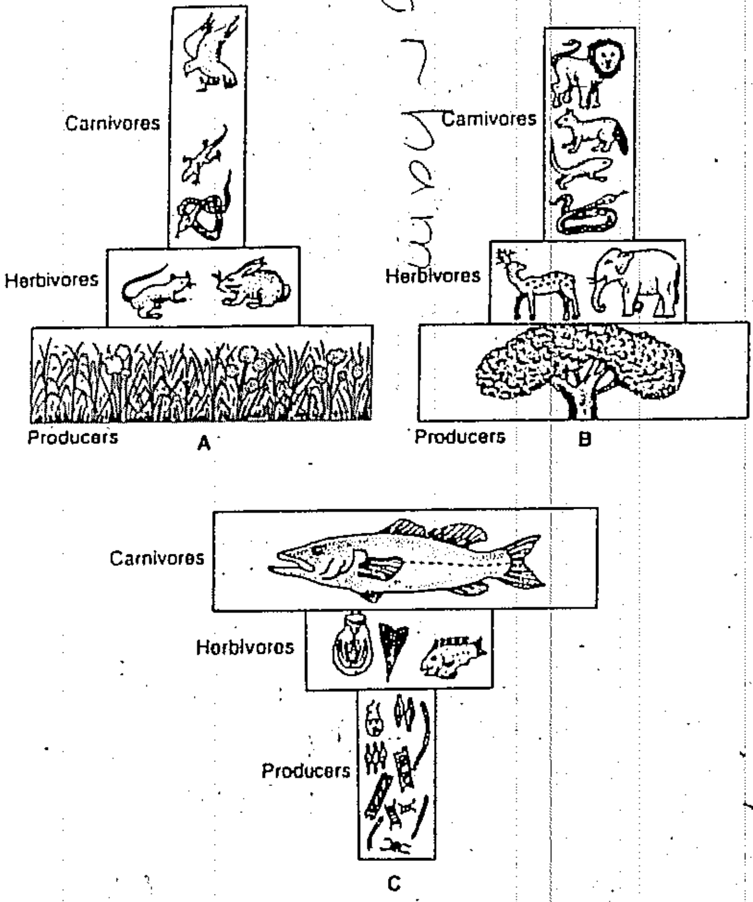

Carnivores
Herbivores
Producers
A
Carnivores
Herbivores
Producers
B
Carnivores
Herbivores
Producers
C

Fig. 26.3. Pyramids of biomass in different ecosystems A. Grassland ecosystem B. Forest ecosystem C. Pond ecosystem

- Ecosystems having this type of food-chains are not directly dependent on solar radiations, *e.g.*,

In lake, freshly fallen litter (organic matter) →Decomposers or Saprobes ⟶Detrivores ⟶ Game fish (top consumers).

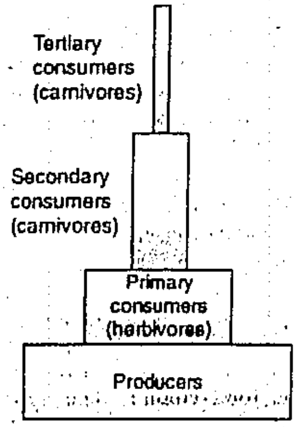

Tertiary consumers (carnivores)
Secondary consumers (carnivores)
Primary consumers (herbivores)
Producers

Fig. 26.4. Pyramid of energy in any ecosystem

Food web

Food-chains never occur independently in ecosystem but various food-chains are interconnected with each other forming an interlocked system, which is known as **food web.**

- ○ Food webs are very important in maintaining equilibrium (homeostasis) of ecosystem.

A food web in grassland ecosystem having different food-chains is shown in figure.

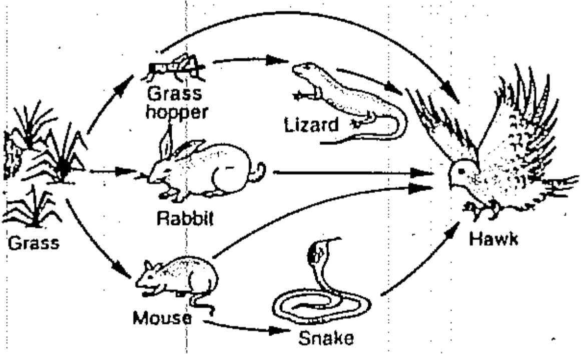

Grass
Grass hopper
Lizard
Rabbit
Hawk
Mouse
Snake

Fig. 26.5. Food web in a grassland ecosystem

Energy flow in ecosystem

- Only 1–4% of the total solar energy is utilized by plants for photosynthesis. Rest of the solar energy is reflected back, absorbed by ground, water and atmosphere.
- Sugar cane is the most efficient user of the solar energy, *i.e.*, 10–12%.

There are two main points in energy flow in an ecosystem:

1. Energy flow is **unidirectional**, *i.e.*, from producers to secondary consumers and not back.
2. Energy goes on decreasing with each and every trophic level, *i.e.*, energy of the producers > primary consumers > secondary consumers > tertiary consumers.

- ○ **Lindemann** gave the law of 10% for energy flow (10% energy transfer law), *i.e.*, only 10% of total energy received by one trophic level is transferred to next trophic level.
- Energy contents are determined by igniting the plant contents in O_2 **bomb calorimeter.**

Productivity of ecosystems

- Net Primary Productivity (NPP) of land = 10.9×10^{10} tons/year.
- NPP of ocean = 5.5×10^{10} tons/year.

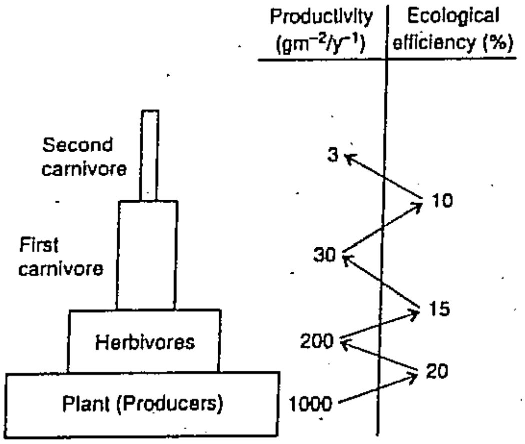
(NPP of oceans is about half of that of land, *i.e.*, land is more productive).

- Lowest productivity is of deserts, *i.e.*, 3 g/msq/ year.
- Highest productivity on land is of tropical rain forests, *i.e.*, 5 kg/msq/ year.

Ecological efficiencies

The percentage of energy in the biomass produced by one trophic level that is incorporated into the biomass produced by the next higher trophic level is called ecological efficiency.

As **Lindemann** (1942) pointed out that the amount of energy reaching each trophic level depends on the net primary production at the base of food chain and on the efficiencies with which animals convert food energy into their own biomass energy through growth and reproduction at each higher trophic level. Of the light energy assimilated by photosynthesis, plants use 15–70% for their maintenance and thus making that portion unavailable to consumers. Herbivores and carnivores are more active than plants and use more of their assimilated energy on maintenance. Hence, the productivity of each trophic level is typically only 5–20% that of the level below it. **The percentage of energy transferred from one trophic level to the next is called 'ecological efficiency' or 'food-chain efficiency', between those two levels.** Let us consider a food chain represented by an ecological pyramid:



For this particular system, ecological efficiencies are 20%, 15% and 10% between trophic levels. But these values vary widely among communities and ecosystems.

- Ecological efficiency is the product of efficiencies with which organisms exploit their food resources and convert them into biomass, *i.e.*, product of exploitation, assimilation and net production efficiencies.

Ecological efficiency = Exploitation efficiency
× Assimilation efficiency
× Net production efficiency

where **exploitation efficiency** is the efficiency with which the biological production of an entire trophic level is consumed. For a particular ecosystem, exploitation efficiency of the prey would be the proportion of the total prey biomass that is eaten or exploited by predators. The **assimilation efficiency** is the proportion of the consumed energy that is assimilated and **net production efficiency** is the efficiency with which assimilated energy is incorporated into growth, storage and reproduction.

- The length of food-chains is limited by ecological efficiencies. Ecological efficiencies are usually lower in terrestrial habitats as compared to aquatic communities. The number of trophic levels is lesser in terrestrial ecosystems, *e.g.*, about 3 for tropical forests, 4 for grasslands, 5 for coastal marine community and 7 for open ocean community.

Biogeochemical cycles or Material cycles

Some important material cycles are:

1. Carbon cycle

CO_2 in the atmosphere is 0.03% (300 ppm), which is utilized by green plants (autotrophs) in photosynthesis for making their food. The plants are eaten by animals. After their death, both plants and animals are acted upon by decomposers and thus organic substances are broken down into CO_2 and H_2O, which again are utilized by plants. The CO_2 is also returned to atmosphere by the process of respiration of plants and animals.

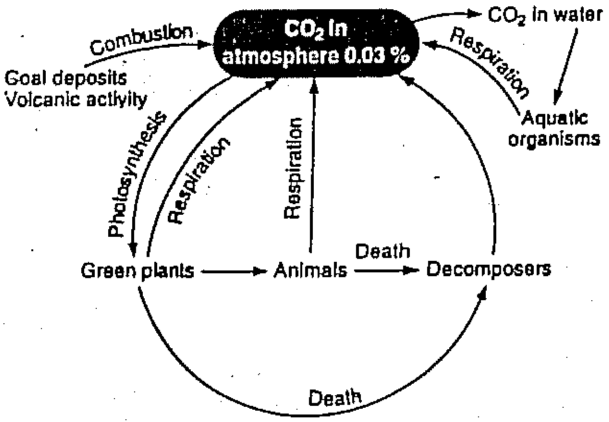


Fig. 26.6. Carbon cycle

C-cycle can be represented in the manner as shown in the figure.

2. Nitrogen cycle

N_2 in the atmosphere is about 79% but plants are unable to use atmospheric N_2. Plants take nitrogen mainly in the form of **nitrates and nitrites**.

- N_2 gas of atmosphere is converted into nitrates and nitrites by process of **nitrogen-fixation**. (Fig. 26.7)
- Physical N_2-fixation or non-biological N_2-fixation occurs by **lightning**. Biological N_2-fixation is of two types:

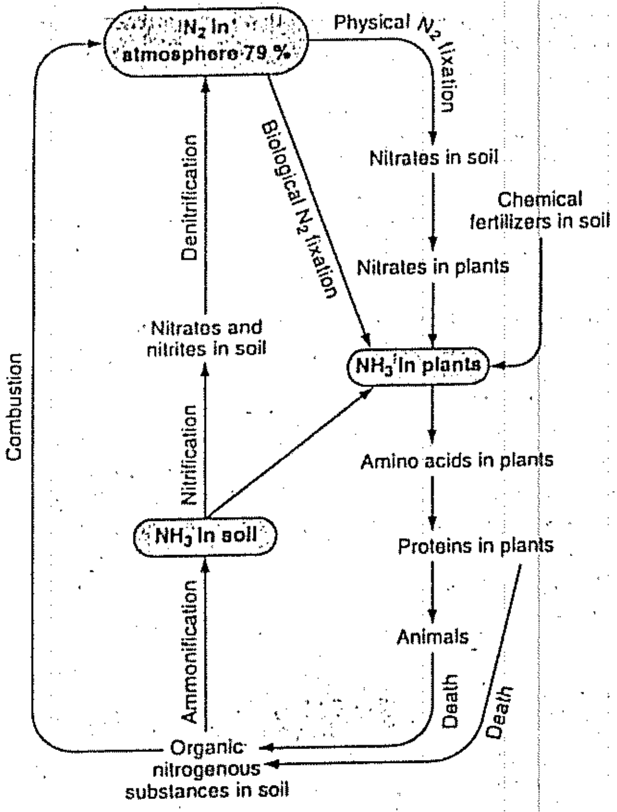

N2 in atmosphere 79 %
Physical N2 fixation
Nitrates in soil
Chemical fertilizers in soil
Nitrates in plants
Biological N2 fixation
Denitrification
Nitrates and nitrites in soil
NH3 in plants
Combustion
Nitrification
Amino acids in plants
NH3 in soil
Proteins in plants
Ammonification
Animals
Death
Death
Organic nitrogenous substances in soil

Fig. 26.7. Nitrogen cycle

(a) **Symbiotic N_2 fixation :** By symbiotic N_2-fixing bacteria, *i.e., Rhizobium leguminosarum* living in the root nodules of all legumes and some non-legumes.

(b) **Non-symbiotic N_2 fixation :** By free living N_2-fixing bacteria like *Azotobacter, Clostridium, Rhodospirillum, Chromatium* and also by blue-green algae (cyanobacteria).

Ammonification : Conversion of organic nitrogenous substances in soil into NH_3 (ammonia) in soil is called **ammonification, which is due to ammonifying bacteria,** *e.g., Bacillus mycoides, B. vulgaris* and *B. ramosus*, etc.

Nitrification : Conversion of NH_3 in soil into nitrates and nitrites is called **nitrification, which is done by nitrifying bacteria,** *e.g., Nitrosomonas, Nitrosococcus* (convert NH_3 into nitrites) and *Nitrobacter* (convert nitrites into nitrates).

Denitrification : Conversion of nitrates and nitrites in soil into atmospheric N_2 is called **denitrification,** which is done by **denitrifying bacteria,** *e.g., Micrococcus denitrificans* and *Bacillus denitrificans.*

3. Sulphur Cycle

In nature, sulphur mainly occurs in elemental form as metal sulphides and sulphates. It is released by weathering of rocks, erosional run off, decomposition of organic matter, etc. Also, it occurs in gaseous form as H_2S which is released into the atmosphere from lakes, continental shelf, marshes or water logged soils. It is quickly oxidised to SO_2. SO_2 comes back to the earth as H_2SO_4 after getting dissolved in rain water.

Starting with photosynthesis, plants pick up sulphur in the form of sulphate which is utilized by them in the synthesis of amino acids like cysteine, cystine and methionine. From plants it is transferred to the consumers. Excretion and dead bodies of the organisms carry it back to the earth. The same is broken by the decomposers to release H_2S under anaerobic conditions, sulphates under aerobic conditions or occasionally as elemental sulphur. Colourless sulphur bacteria (*e.g., Beggiatoa*) oxidise H_2S to elemental sulphur and then to sulphuric acid. The photosynthetic green bacteria (*e.g., Chlorobium limicola*) can carry the reduction of H_2S to elemental sulphur. The purple bacteria (*e.g., Thiopedea rosea, Rhodopseudomonas palustris*) oxidise H_2S to sulphates which may be recirculated and taken up by the producers.

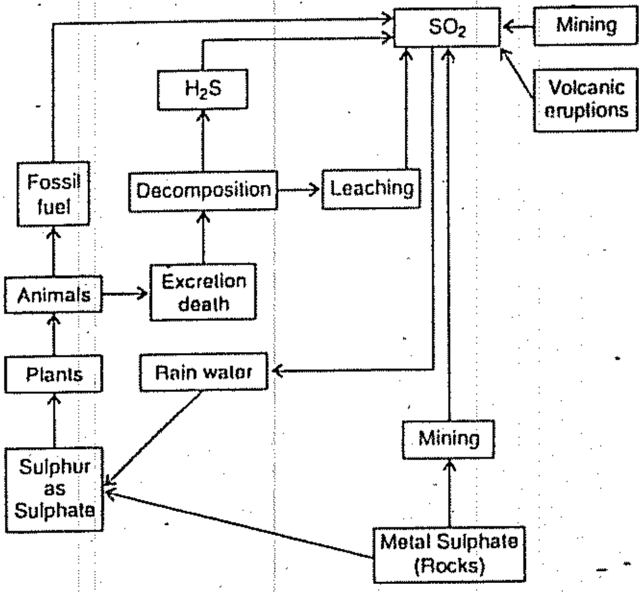

SO2
Mining
Volcanic eruptions
H2S
Fossil fuel
Decomposition
Leaching
Animals
Excretion death
Plants
Rain water
Mining
Sulphur as Sulphate
Metal Sulphate (Rocks)

Fig. 26.8. Sulphur cycle

4. Phosphorus cycle

Phosphorus mainly occurs as phosphate in the soil under undisturbed natural conditions. It also occurs in secondary forms as compounds of calcium and iron, and in organic combination. Atmospheric or gaseous cycle is absent.

Phosphates present in the soil occur in insoluble form. It is dissolved by chemicals secreted by microorganisms and plant roots.The dissolved phosphate is absorbed by the plants and changed to organic form. From plants, phosphorus is transferred to animals. Animal excretions and dead bodies are acted upon by decomposers and phosphorus is released in the process. The same becomes available for reutilization by plants. Inside soil some phosphorus is lost through leaching. A good amount of phosphorus combines with calcium, iron or aluminium and becomes insoluble. It settles down at the bottom of lakes or oceans as sediments. Bones and teeth also remain undegraded. Such phosphorus becomes a part of lithosphere. It is released after a long time when the rocks containing them are exposed to weathering or mined.

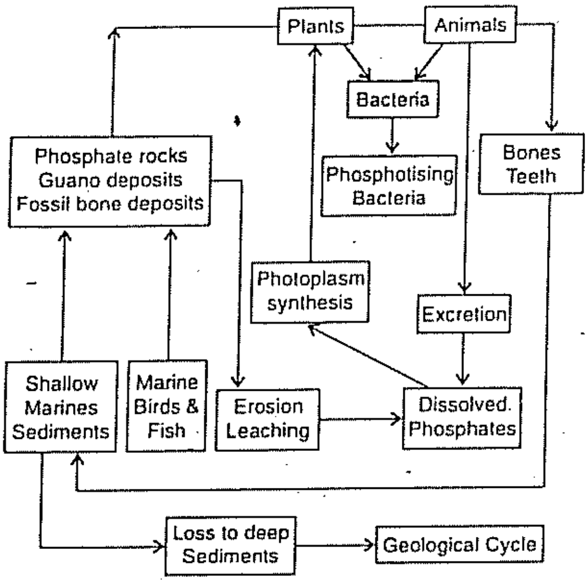


Fig. 26.9. Phosphorus cycle

Major biomes

A **biome** is a major terrestrial community characterized by a distinct climate and inhabited by a particular species of plants and animals. In other words, biomes are ecosystems of plants and animals that occur over wide areas of land within specific climatic regions and are easily recognized by their overall appearance. Each biome is similar in its structure and appearance wherever it occurs on earth and differs significantly from other biomes. Biomes are sometimes named by the climax vegetation of the region, *e.g.*, tropical rain forest. The characteristics of biomes are a direct result of their temperature and rainfall patterns.

Biomes are often classified in seven categories:

1. Tropical rain forests
2. Savannahs
3. Deserts
4. Temperate grasslands
5. Temperate deciduous forests
6. Taiga
7. Tundra

The distribution of the seven biomes of the world is correlated to climate, which is affected by latitude, presence of mountains, temperature of surrounding sea and the elevation of the land.

1. Tropical rain forests : The tropical rain forest, a biome occurs in regions of high temperature (average 25°C) and high rainfall (200–450 cm per year). These tropical rain forests occur in Central America, around Amazon basin in South America, in Africa and in South-East Asia.

- This biome is characterized by **multistoried vegetation** (upto five distinct layers or storeys of vegetation). Further **maximum biodiversity** on land is shown by this biome and it is estimated that one half to two-thirds of all species of terrestrial plants and insects live in tropical forests.
- **Lianas** (vascular plants rooted in soil and they only get support of trees for climbing to top) and **epiphytes** (air plants) are common in this biome due to excess of **moisture**. Further giant trees of the tropical forest support a rich and diverse community of animals on their branches.
- The roots of the trees spread out from thickened trunks into a thin layer of soil, often no more than a few cm deep. These roots transfer the nutrients from fallen leaves and organic debris quickly and efficiently back to the trees after bacteria and fungi breakdown. the debris and very few nutrients remain in the soil and thus, land becomes barren after cutting down these trees.
- No one species dominates in this biome.
- The productivity of this biome is maximum.
- The trees of this biome possess **Buttressed trunks** and phenomenon of **cauliflory** (presence of flowers and fruits on main trunk and main branches) is common in this biome.

2. Savannahs : Like tropical forests, savannahs are found near the equator but in areas having less annual rainfall (90–150 cm/year). Some areas near the equator experience prolonged dry seasons. The heat, periodic dryness and poor soils cannot support a forest but have led to evolution of tropical **open grasslands with scattered shrubs and trees, the savannahs.** These areas situated between the tropical rainforests and deserts cover much of central and Southern Africa, Western India, Northern Australia, Northern and East-Central South America and some of Malaysia.

- The vegetation of this biome support large grazing herbivores like buffalo, zebra, etc., which are food for carnivores like lions, tigers, etc. The savannah also supports a large number of plant eating invertebrates like mites, grasshoppers, ants, beetles and termites.
- The **termites** are one of the most important soil organisms in savannah.
- Indian tropical grasslands are not true savannahs but these are the result of destruction and modification of tropical deciduous forests by cutting, grazing and fire.

3. Deserts : These are the biomes that have 25 cm (10 inches) or less of precipitation annually. Major deserts occur around 20–30 degrees north and south latitude, where the warm air arising from the equator falls. Deserts are present in South-West USA, Mexico, Central and West Australia, coastal area of Chile and Peru and Tibet in north of Himalayas.

- **Sahara** of North Africa, **Thar** of West Asia and **Gobi** of Asia are most important deserts.
- Annual plants are abundant in deserts and tide over unfavourable dry season in the form of seeds. Succulent plants are characteristics of deserts. Trees and shrubs present in deserts have deep roots.
- Desert animals have also fascinating adaptations that enable them to adjust with limited water supply.
- Desert plants show phenomenon of **Allelopathy,** *i.e.*, they secret some chemical substances which inhibit the growth of plants growing in their near vicinity.
- Deserts show poor biodiversity and their productivity is minimum.

4. Temperate grasslands : Temperate grasslands experience a greater amount of rainfall than deserts but a lesser amount than savannahs. They occur at higher latitudes than savannahs but like savannahs are characterized by perennial grasses and herds of grazing mammals.

- Temperate grasslands have different names in different parts of the world, *e.g.*, **Prairies** of North America, **Steppes** of Russia, **Veldts** of South Africa, **Pampas** of South America, **Pusztas** of Hungary and **Tussocks** of New Zealand.
- Soil in temperate grasslands in rich and much of temperate grasslands are formed for this season. Many of the rich agricultural lands in United States are Southern Canada were originally occupied by Prairies.

5. Temperate deciduous forests : Temperate deciduous forests occur in areas having warm summers, cold winters and moderate amount of precipitation (75–150 cm annually). The trees of this forest loose their leaves during autumn and remain dormant throughout winter (term 'deciduous' derived from Latin word meaning 'to fall'). These forests are present in Eastern United States, Canada and extensive region in Eurasia.

- In temperate forest biome, there is an upper canopy of dominant trees like beech, oak, birch, maple, etc., followed by lower tree canopy and then a layer of shrubs beneath.
- Animal life in this biome is abundant on the ground as well as on the trees.

6. Taiga : The taiga or northern coniferous forests or boreal forests consist of evergreen, cone bearing trees like spruce, hemlock and fir and extend across vast areas of Eurasia, and North America.

- The taiga is characterized by long, cold winters with little precipitation.
- The harsh climate limits productivity of the taiga community. The cold temperatures, very wet soil during the growing season and acids produced by fallen conifers needles and sphagnum inhibit full decay of organic matter, due to which thick layers of semidecayed organic material called peat is formed, which acts as energy source.

7. Tundra : The tundra encircles the top of the world. This biome is characterized by desert like levels of precipitation (less than 25 cm annually), extremely long and cold winters and short warmer summers. Farthest north in Eurasia, North America and their associated islands (between taiga and permanent ice) is the open and often boggy or marshy community called tundra.

- This biome covers 1/5th of earth's land surface.
- Tundra is uniform in appearance and is dominated by scattered patches of grasses, sedges and lichens. Some small trees do grow but are confined to margins of streams and lakes (In general treeless).
- Tundra is a biome of low diversity and low productivity.
- The precipitation that falls remains unavailable to plants for most of the year because it freezes. During the brief arctic summer, some of the ice melts and **permafrost** (or permanent ice) found about a meter down from the surface, never melts and is impenetrable to both water and roots. However, the alpine tundra found at high elevation in temperate or tropical regions does not have this layer of permafrost.

WATER ECOLOGICAL ADAPTATIONS

Water as an important ecological factor was first recognized by **Warming.** On the basis of water requirement, plants are divided into three major types:

(A) Hydrophytes or Water plants.
(B) Xerophytes or Plants growing in xeric (dry) condition.
(C) Mesophytes or Plants growing in mesic (normal water) conditions.

Xerophytes are further divided into different types:

(a) **Oxylophytes :** Plants growing on acidic soil.
(b) **Psychrophytes :** Plants growing on cold soil.
(c) **Halophytes :** Plants growing on saline soil.
(d) **Lithophytes :** Plants growing on rocks.
(e) **Chersophytes :** Plants growing on waste land.

(f) **Eremophytes :** Plants growing in deserts and steppes.
(g) **Psilophytes :** Plants growing in savannah.
(h) **Helophytes :** Plants growing in mud.

(A) Hydrophytes

[Greek-*Hydor* + *Phytes*]
↓ ↓
Water Plants

These are the plants growing in extremely wet or watery conditions. Hydrophytes are further subdivided into five main types:

(i) **Free floating hydrophytes :** They are not rooted in soil and mud. These hydrophytes float freely on the surface of water, *e.g., Eichhornia* (water hyacinth) *Lemna, Wolffia* (minutest duck weed), *Azolla, Salvinia*, etc.

(ii) **Rooted hydrophytes with floating leaves :** These have roots fixed in mud but the leaves keep on floating on the water surface, *e.g., Trapa, Nymphaea, Nelumbo, Marsillea*, etc.

(iii) **Rooted submerged hydrophytes :** The hydrophytes, which are rooted in mud at bottom and remain under water, *e.g., Hydrilla, Vallisneria, Potamogeton, Isoetes*, etc.

(iv) **Submerged floating hydrophytes :** These plants remain under water completely and are not rooted in the mud, *e.g., Ceratophyllum* (roots completely absent, even in embryonic stage), *Utricularia, Najas*, etc.

(v) **Rooted emergent hydrophytes or Amphibious plants :** In these plants the root is fixed in soil and stem remains partly or completely exposed to air, *e.g., Ranunculus, Typha, Scirpus, Cyperus, Carex, Sagittaria*, etc.

Ecological adaptations of hydrophytes

(a) Morphological adaptations

(i) In hydrophytes roots are of secondary importance so they are poorly developed.

(ii) Root hair are absent or poorly developed.

(iii) Root cap is absent in hydrophytes, although in *Eichhornia*, in place of root cap, **root pocket** or **root sheath** is present which is protective in function.

(iv) Stem is spongy, flexible and soft.

(v) Leaves are thin, ribbon like, *e.g., Vallisneria*, large and flat in *Nymphaea* and *Nelumbo* and much dissected in *Ceratophyllum.*

In some plants, leaves of two types are present. The leaves below water are narrow and with cut or dissected margins, whereas leaves above water are broader and with entire margins. This phenomenon is called **heterophylly**, *e.g.*, in *Sagittaria, Ranunculus, Salvinia, Azolla, Limnophilla*, etc.

(vi) Large amount of mucilage is present on submerged leaves, the function of which is to prevent decay under water.

(vii) Flowers and seeds are poorly developed.

(b) Anatomical adaptations

(i) Single layered, thin-walled epidermis is present.

(ii) Cuticle is absent.

(iii) Aerenchyma (parenchymatous or thin-walled cells with air cavities) is well developed, which help in buoyancy or floating.

(iv) Stomata are either absent or poorly developed. In hydrophytes with floating leaves, stomata are present on upper surface of leaves.

(v) Mesophyll tissue is not differentiated into palisade and spongy parenchyma.

(vi) Chlorophyll is present in almost all parts of plants.

(vii) Vascular tissue (xylem and phloem) is poorly developed.

(viii) Mechanical tissue is poorly developed.

In submerged hydrophytes gaseous exchange and mineral uptake occur through general surface.

- In these plants osmotic pressure is equal or slightly higher than surrounding water.

(B) Xerophytes

The plants which grow in dry or xeric conditions or where availability of water is negligible, are known as xerophytes. Xerophytes are mainly of three types :

(a) **Ephemeral annuals or Drought evaders or Drought escapers :** These plants complete their life span in very short period before approach of actual dry conditions. These are not true xerophytes, *e.g., Argemone mexicana, Solanum xanthocarpum, Tephrosia purpurea, Cassia tora*, etc.

(b) **Succulents :** These xerophytes store water in their roots or stem or leaves for drought periods, so they face only external dryness and not internal dryness, hence are not true xerophytes.

- Succulents storing water in roots, *e.g., Asparagus* and *Ceiba parviflora.*
- Succulents storing water in stem, *e.g., Opuntia, Cocoloba.*
- Succulents storing water in leaves, *i.e.*, **malacophyllous** xerophytes, *e.g., Begonia, Agave, Tradescantia, Bryophyllum*, etc.

(c) **Non succulents :** These xerophytes face both external and internal dryness and hence called **true** xerophytes, *e.g., Acacia, Zizyphus, Capparis, Calotropis, Prosopis, Salvadora, Nerium*, etc.

Ecological adaptations in xerophytes

(a) Morphological adaptations

(i) In xerophytes, extensively developed long root is present, *e.g.*, in *Calotropis* and *Prosopis*, roots may go upto 30 metre deep in search of water.

(ii) Both root hair and root caps are well developed.

(iii) Stem is stunted, hard, tuff and woody with thick bark.

- In some cases stem is modified into flattened leaf like structure called **phylloclade**, *e.g., Opuntia, Cocoloba* (*Muehlenbechia*).

(iv) Leaves are generally small and scaly. In some cases they are thick and leathery. Sometimes leaves are modified into spines to reduce water loss.

- In some plants, *e.g.*, *Acacia* and *Parkinsonia*, petiole is modified into leaf like structure called **phyllode.**

(v) In xerophytes leaves and stem are having hairy and waxy covering.

(vi) Leaf surfaces are shining and glazed so as to reflect light.

- In leaves of xerophytic grasses, there are present **bulliform cells or motor cells** on upper epidermis which help in rolling of leaves so as to reduce transpiration, *e.g.*, *Agropyron*, *Poa*, *Psamma*, *Ammophila*.

(b) Anatomical adaptations

(i) In xerophytes aerenchyma is lacking.

(ii) Epidermal cell walls are thick.

(iii) Thick cuticle is present in these plants.

(iv) Stomata are generally present on the lower surface of leaf and are **sunken.**

(v) Mesophyll is well differentiated into palisade and spongy parenchyma.

(vi) Vascular tissue is well developed in xerophytes.

(vii) Mechanical tissue is very well developed.

(c) Physiological adaptation

(i) Xerophytes have high osmotic pressure.

- **Cladode :** In some plants, like *Asparagus* and *Ruscus*, axillary branches are modified into leaf like structures which are known as cladode.

(C) Mesophytes

Mesophytes are the plants of mesic or normal conditions. These plants grow in moist and well aerated soils.

(D) Halophytes

Halophytes are the plants which grow in saline condition or in high salt concentration of generally NaCl, $MgCl_2$, $MgSO_4$, etc. These plants thus **face physiological dryness.**

Halophytes grow in saline soils where marshy or muddy conditions are present.

- One of the most important example of halophytes is **mangrove vegetation** which is present in littoral swampy zones of Mumbai, Kerala, West Bengal and Andaman Nicobar islands.
- Sunderbans of West-Bengal are the examples of mangrove vegetation.
- Important plants of mangrove vegetation are: *Rhizophora mangi, Rhizophora mucronata, Sonneratia, Avicennia, Ceriops, Aegiceras*, etc.

Distinctive features of mangrove vegetation are:

(i) Presence of pneumatophores or Breathing roots or Respiratory roots : Mangrove plants grow in water logged marshy conditions so there is problem of aeration in roots of these plants. Because of this some branched, negatively geotropic roots come out of the mud which are known as pneumatophores. These roots have minute pores for gaseous exchange which are called **pneumathodes or breathing pores or lenticels.**

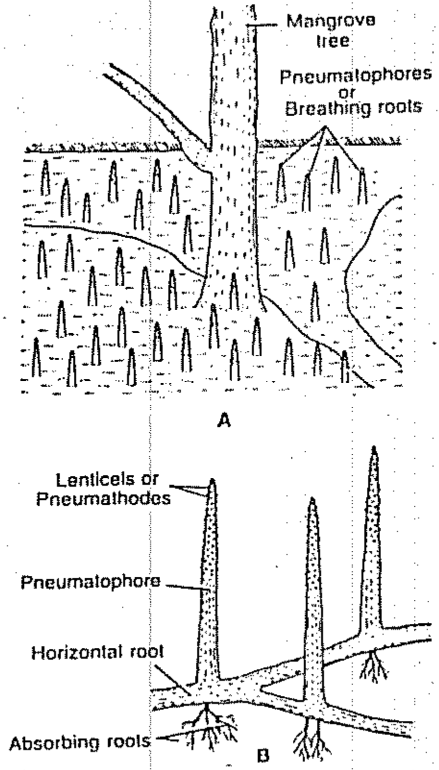


Fig. 26.10. A–B. Pneumatophores in mangrove vegetation

- No pneumatophores are present in *Rhizophora*, a common plant of mangrove vegetation.

(ii) **Vivipary,** *i.e.*, germination of seeds on the parent plant is known as vivipary. Here seedlings (not seeds) separate from the plant.

(iii) In these plants the **supporting or stilt roots** are present which arise from main trunk.

(iv) Mangrove plants have high osmotic pressure.

ECOLOGICAL SUCCESSION

Communities are never stable but keep on changing. This relatively definite sequence of communities over a period of time in the same area is called **ecological succession.**

- Hult (1885) first of all gave the term ecological succession.
- The term ecosystem development was given to ecological succession by **Odum.**

Basic types of succession

Some basic types of succession are as follows:

(a) Primary succession : It starts from the primitive substratum, where there is no already built living matter.

(b) Secondary succession : The succession which starts from already built substratum, where there was living matter earlier.

According to another classification, the succession is of following types:

(a) **Autogenic succession :** When the succession has begun, the vegetation itself is responsible for replacing itself by changing existing environmental conditions.

(b) **Allogenic succession :** When in succession other conditions (not vegetation itself) are responsible for replacing communities, then it is called allogenic succession.

Depending upon the substratum, succession is of three types:

(a) **Hydrosere or Hydrarch :** Succession beginning in fresh water, *e.g.*, ponds, lakes, streams, etc.

(b) **Xerosere or Xerarch :** Succession beginning in dry conditions. It is further classified into three types:

(i) **Lithosere :** When succession starts on bare rocks.

(ii) **Psammosere :** When succession begins on sand.

(iii) **Halosere :** When succession starts in saline conditions.

(c) **Mesarch :** When succession begins in mesic conditions.

- The first group or community in succession is called as **pioneer community** while the last community being established there is known as **climax community** which is always **mesophytic.**
- Different stages of succession are called seral stages and all these seral stages constitute a sere, *e.g.*,

Hydrosere

I Seral stage or Pioneer community ⟶ Phytoplankton stage (Blue green algae, other algae, bacteria, diatoms, etc.)
↓
II Seral stage ⟶ Rooted submerged stage (*Hydrilla, Vallisneria*, etc.)
↓
III Seral stage ⟶ Rooted floating stage (*Trapa, Nymphaea, Nelumbo*, etc.)
↓
IV Seral stage ⟶ Rooted emergent stage (Amphibious plants)
↓
V Seral stage ⟶ Reed swamp stage
↓
Climax community (Mesophytic) ⟶ Forest stage (*Salix, Populus*, etc.)

Xerosere (Lithosere)

- Pioneer community ⟶ Crustose lichens
↓
Foliose lichens
↓
Moss stage
↓
Herb stage
↓
Shrub stage
↓
- Climax community (Mesophytic) ⟶ Woodland or forest stage

General processes of succession

Succession is completed in following steps :

(a) **Nudation :** Formation of bare area without any form of life is called nudation. The cause of nudation may be climatic, topographic or biotic.

(b) **Invasion :** Successful establishment of a species in this bare area is called invasion. It is completed in three steps:

(a) Migration (b) Ecesis or establishment

(c) Aggregation

(c) **Competetion and coaction :** Competetion may be interspecific or intraspecific.

Intraspecific competetion is called coaction.

(d) **Reaction :** Modification of environment due to organisms in it is called reaction.

(e) **Stabilization :** Finally, the terminal community becomes stabilized in the prevailing conditions.

Age and area hypothesis

This hypothesis was given by Willis (1922). According to this concept, area of distribution of a species is directly proportional to age of species.

Area of distribution ∝ Age of species, *i.e.*, more the age, more is the area of distribution and lesser the age, lesser will be the area of distribution.

ECOLOGICAL INDICATORS OR PLANT INDICATORS

Plants are the index or measure of existing environmental conditions because of their response to these conditions and hence the plants are known as **plant indicators** or **ecological indicators.**

Main points regarding ecological or plant indicators are:

(a) Communities are better indicators than single species.

(b) Dominant and large (steno) species are better indicators than small (eury) species.

Main plant indicators are:

1. Plants indicators of climatic conditions

e.g., **Evergreen plants** are indicators of rainfall throughout the year.

- **Grasslands :** Indicate more rainfall in summer and less in winter.
- **Sclerophyllous plants** (stunted shrubs with leathery leaves) : Indicate more rainfall in winter and less in summer.
- **Xerophytes or Deserts :** Indicate poor or no rainfall.

2. Plants indicators of fertility of land

e.g., *Quercus* (Oak) grows in fertile or productive land and not in sandy poor land, so is indicator of potential productivity of land.

3. Plants indicators of soil type

e.g., *Capparis* (Karil) and *Carissa* : Indicators of soil-erosion.

- *Andropogon* — Indicator of sandy soil.
- *Rumex acetocella* — Indicator of acidic soils.
- *Artemisia, Salicornia* — Indicators of saline soils.

4. Plants Indicators of pollution

- Lichen and mosses are the first plants to die in SO_2 polluted environment and hence act as indicators of air pollution (especially SO_2 pollution). These are thus called **indices of atmospheric purity** (IAP).
- *E. coli, Wolffia, Chara* and *Utricularia* are indicators of water pollution.
- *Daphnia* also serves as an indicator of water pollution.
- **Diatoms** (members of **bacillariophyceae** of algae): Indicate **sewage pollution.**

5. Plants Indicators of overgrazing

e.g., Amaranthus, Chenopodium, Polygonum: Are indicators of **overgrazed conditions.**

6. Plants Indicators of fire

- Plants which grow under fire burnt conditions are called **pyrrophytes.** These act as indicators of fire, *e.g., Marchantia polymorpha* (bryophyte), *Pyronema confluens* (fungus), *Pteridium aquilinum* (pteridophyte), *Pinus contorta* (gymnosperm), *Epilobium* and *Populus tremuloides* (angiosperms), etc.

7. Plants Indicators of mineral deposits

e.g., Equisetum and *Thuja* – Indicate **gold deposits.**

- *Astragallus* – Indicator of **uranium deposits.**

Such plants growing in metal rich conditions are called **metallophytes** or **metalocaulous plants.**

8. Indicators of petroleum deposits

Fusilinds protozoan are indicators of **petroleum deposits.**

SOIL EROSION AND SOIL CONSERVATION

Loss of top fertile soil or disturbance in soil structure is called **soil erosion.** According to **Odum (1966),** soil erosion is a part of soil pollution.

Types of soil erosion

Depending upon the agent which causes soil erosion, it is of following types:

(I) Water erosion : When the soil erosion occurs by agency of water. It is of following types:

(a) Sheet erosion : Loss of thin, uniform layer of soil by water is called sheet erosion.

(b) Rill erosion : Thin channels in the form of finger like grooves formed by running water are called rills and this type of erosion is called rill erosion.

(c) Gully erosion : Thin channels and rills become wider by fast running water are called gullies (wide channels) and this type of soil erosion is called gully erosion.

(II) Wind erosion : Wind erosion is common in dry areas or deserts and in soils which are lacking vegetation cover.

(iii) Land slides or Slip erosion : Due to heavy rains the rocks become heavy and then assisted by gravity, they slip down. This type of soil erosion is called slip erosion.

(iv) Stream bank erosion or Riparian erosion : River banks or stream banks are cut down by flowing rivers and streams especially at curves. This type of erosion is known as riparian erosion.

(v) Deforestation or Overgrazing : Excessive falling of trees and overgrazing remove the vegetation cover and then the soil can be easily taken away by water and wind.

Soil conservation

Soil erosion can be prevented by some methods and this is called **soil conservation.**

Soil conservation can be done by following methods:

(A) Biological methods

Soil conservation by use of plants or vegetation is called biological method.

(i) Agronomic practices : In such regions where good agronomic conditions occur, soil is protected by growing vegetation. These agronomic practices are:

(a) Contour farming : In hilly regions, alternate ridges and furrows are made at right angles to the slopes. Ridges at same level are called contour. The flow of water is checked by furrows. This is called contour farming.

(b) Mulching : The basal portion of stalks of herbaceous plants are left in soil after harvesting are called **mulches** and this phenomenon is called mulching. Mulching is helpful in retaining soil moisture, in checking soil erosion and maintaining fertility of soil.

(c) Crop rotation : If the same crop is grown year after year, fertility of soil is lost due to utilization of same minerals again and again, thus disturbing the soil structure, which facilitates soil erosion. So crop rotation is necessary to check soil erosion.

(d) Strip farming : To grow the plants in rows is called strip farming. The rows of plants check flow of water and thus check soil erosion.

(ii) Dry farming : Dry farming is common in such areas where water availability is poor. In these areas such crops are grown which require less water, *i.e.,* dry farming crops, *e.g.,* bajra, arhar, gram, etc.

(iii) Agrostological methods : To check soil erosion, grasses like *Cynodon* (doob grass) are grown in between the rows of crop plants. These methods constitute agrostological methods.

(B) Mechanical methods

Besides biological methods, mechanical methods are also used to check soil erosion. Some of them are:

(i) Bench terracing : This method is applied in hilly areas. Fields are prepared in ladder like fashion. This prevents rapid flow of water hence soil erosion is prevented.

(ii) Basin listing : Small basins are constructed which not only retain water but also reduce its velocity.

(iii) **Contour terracing :** A channel is formed along the slope which changes the way of run off water.

(iv) Bunds, dams, etc., are constructed to prevent soil erosion.

(v) Stream bank protection is done to check the erosion.

(vi) **Afforestation :** It means to grow more and more plants because trees acts as **wind breaks** and also bind soil particles. For this purpose, the important plants grown are: *Lawsonia alba, Calotropis gigantea, Thevetia neriifolia, Acacia arabica, Acacia catechu, Prosopis juliflora*, etc.

- Most important soil binder plant in North-West India (Rajasthan) is *Prosopis juliflora.*
- **Chipko movement** or **Tree hugging movement** was started by **Sundar Lal Bahuguna** in 1972. The women of Advani village of Garhwal tied threads around the trees and pledged to save them.
- Van-Mahotsav was started by **K. M. Munshi** in 1950.
- **Richard St. Barbibaker** is known as **'tree saint in India.'**

POLLUTION

Odum defined Pollution as, 'Undesirable change in physical, chemical and biological properties of air, water and soil, which directly or indirectly affect human beings.'

- (Contamination is presence of harmful micro-organisms or their products, causing various disorders or diseases.)

Some workers are of the opinion that pollution is nothing but it is **population**, *i.e.*, pollution is the result of man's activity.

- Pollution causing agents or substances are called **pollutants** and these pollutants are basically of two types:

1. Biodegradable or Degradable pollutants or wastes :

These are also called **non-conservative pollutants**. These are decomposed chemically or by activity of micro-organisms into harmless products and are recycled back into the atmosphere.

e.g., sewage and sludge (solid part of sewage is called sludge).

2. Non-biodegradable or Conservative or Non-degradable pollutants or wastes

These are **persistent pollutants** and are not decomposed naturally or by activity of micro-organisms and thus are not recycled back into the atmosphere. Further their **biological magnification** occurs, *i.e.*, their concentration goes on increasing with each and every trophic level in a food chain. *e.g.*, long chain phenolic compounds, glass, plastics, aluminium cans, heavy metals like nickel, lead, mercury, chromium and pesticides like DDT, etc.

Types of pollution

Pollution is of following basic types:

1. Air pollution

Air pollution is due to excess of different gases, smoke, particulate matters (dust, etc.), chemicals, aeroallergens (pollens, spores), etc.

- Important **primary air pollutants** (which are released directly) are CO, SO_2, NO_x (oxides of nitrogen), HF, etc., whereas **secondary air pollutants** (formed by interaction of primary air pollutants) are O_3 (ozone), peroxy-acetyl nitrate (PAN), etc.

$$\text{Oxides of nitrogen + unburnt hydrocarbons} \xrightarrow{\text{UV-rays}} O_3 + \text{PAN (Secondary air pollutants)}$$

- Most important gaseous air pollutant is SO_2 (sulphur dioxide). SO_2 is produced due to combustion of fossil fuels (coal and petroleum products) as well as smelting of sulphide containing ores.
- SO_2 enters into leaves of plants through stomata and combine with water in intercellular spaces to form sulphurous acid (H_2SO_3) and thus form **sulphites.** Excess of sulphites is the cause of SO_2 injury in plants.
- SO_2 affects the plants adversely as follows:

(a) By altering or changing the permeability of membranes by efflux of K^+ ions.

(b) $$SO_2 + H_2O \rightleftharpoons \underset{\text{(sulphurous acid)}}{H_2SO_3} \rightleftharpoons H^+ + HSO_3^-$$

H^+ knocks out Mg from tetrapyrollic ring structure of chlorophyll molecule and thus converts the chlorophyll molecule into inactive brown pigment called **phaeophytin** which reduces photosynthetic rate. Formation of phaeophytin is called **phaeophytization.**

(c) SO_2 acts as competitive inhibitor of CO_2 on **RuBP-carboxylase** and **PEP-carboxylase** enzymes (key enzymes of photosynthesis) and thus photosynthesis is inhibited.

- SO_2 injury appears in the form of interveinal, bifacial, necrotic, brownish patches mostly on mature leaves.
- SO_2 above 1 ppm affects human beings in terms of irritation of eyes, respiratory tract damage, bronchitis, asthama, etc. Maximum SO_2 pollution in India occurs in Kolkata.
- SO_2 has also adverse effect on buildings, sculptures, painted surfaces, etc., where it causes discoloration and deterioration. Yellowing and blackening of Taj Mahal at Agra is due to SO_2 and other pullutants released by Mathura refinery, which is called **'Stone Cancer'.**

Automobiles account for 60% of air pollution. In Delhi, Kolkata and Mumbai, automobiles account for 80% of air pollution. Main gaseous air pollutants released by automobiles are CO (carbon-monoxide), NO_X (oxides of nitrogen), 3, 4-benzpyrene, NH_3 and Pb (lead).

- (Fly ash, *i.e.*, burnt out particles, is not present in automobile exhaust)
- CO is released in incomplete combustion of petroleum products and automobiles are responsible for production of 74% of total man-made CO in atmosphere. Carbon monoxide acounts for 50% of total air pollutants. CO reduces oxygen carrying capacity of the blood and thus causes **asphyxiation.** Maximum CO concentration is present in Kolkata (35 ppm), followed by Kanpur (30 ppm).
- Lead (Pb) is released by combustion of petrol as **tetra ethyl lead** is used as antiknock in petrol. This lead is very harmful and causes **plumbism or lead poisoning,** which disturbs nervous system, liver, kidneys in adults and also causes brain damage in children.
- 3,4-benzpyrene released mainly in idling of automobiles, causes lung cancer.
- HF (hydrogen fluoride) is another air pollutant which is released in ceramics industry, aluminium refineries, etc. High HF concentration causes a disease called **fluorosis** in animals including human beings, in which tooth decay, knee bone swelling and ill-health occur. Injury symptoms of HF on plants are present on leaf **tips and leaf margins.**
- O_3 and PAN, the secondary air pollutants have also adverse effects. PAN causes eye-burning and checks hill-reaction of photosynthesis.

Aeroallergens : Pollens and spores of some plants are also present in atmosphere which are also causes of air pollution, constitute **aeroallergens.** They cause allergy in human beings.

Aerosols : Both liquid and solid aerosols are present in atmosphere, which are called **particulate matter** by Hodges (1973). Chemicals released in the atmosphere with force in the form of **mist or vapours** are called aerosols. Jet-aeroplanes release aerosols, which contain CFC (chlorofluorocarbons). It is strong enemy of ozone and causes **depletion of ozone layer.** Due to depletion of ozone layer, harmful UV-rays enter into the atmosphere and cause harm to human beings in form of **skin cancer.** A hole in ozone layer has been created in south pole (Antarctica) and according to one estimate, ozone layer has been depleted by about 14%.

- In **'Earth summit'** held in 1992 in **Rio-de-Janeiro** (Brazil), the whole world has adopted a proposal to stop use of CFC by the end of 2000.

Smoke : About 15% of air pollution is caused by smoke, which is released mainly by industries and also by burning of coal, wood, tobacco, etc.

- Fog turned dark and heavy by smoke is called **smog.** Smog is of two types, *i.e.*, **classical smog** and **photochemical smog.** Classical smog (London smog) is also known as **sulphur smog,** because it has excess of sulphur and its main components are smoke, dust particles, SO_2 and H_2S. Photochemical smog (Los-Angeles smog) on the other hand is a yellowish brown, opaque smog, which is formed as a result of photochemical reaction between hydrocarbon and oxides of nitrogen and results in production of secondary pollutants like O_3, PAN, phenols and aldehydes.

Green house effect : Due to heavy industrialization and transportation (modernization), CO_2 concentration is increasing day by day in the atmosphere. CO_2 has capacity of absorbing heat radiations and thus **increases temperature.** This increase in global temperature (global warming) is mainly due to CO_2 concentration is called **'green house effect'.**

- Besides CO_2, other important gases associated with green house effect are CH_4 (methane), oxides of nitrogen (NO_x), CFC (chlorofluorocarbons) and O_3 (ozone) and these are called **'green house gases'.** Because CO_2 and other gases absorb infrared radiations (heat) of sun like glass does in green house and thus natural trapping of heat in atmosphere is called green house effect and the gases absorbing infrared radiations are called green house gases.

Relative contribution of these gases to global warming are:

CO_2	—	50%
CFC	—	20%
Methane (CH_4)	—	16%
Ozone (O_3)	—	8%
Nitrous oxide	—	6%

So, it is clear that minor green house gases together have warming effects almost equal to that of CO_2.

It is estimated that by the end of 2100 A.D., atmospheric temperature will be increased by 1-5°C. As a result of increase in global temperature, the ice caps will melt and whole earth will be under water.

- (According to one report, CO_2 concentration has increased upto 367 ppm in 1998 as against 280 ppm in 1800. It is estimated by scientists that by 2050 the concentration of atmosphere CO_2 will be doubled to that what it was in 1700s)
- Albedo or increase in shineness of earth due to increase in particulate matters in the atmosphere decreases atmospheric temperature due to reflection of light rays.

Global warming and sea level rise : There can be major thawing or melting of glaciers and polar ice caps, if the overall temperature of earth increases by just a few degrees. As a result of global warming, Antarctic peninsula (world's largest land-bound ice) decreased by thousands of square kilometers during December 1998 to March 1999. Ice-covered ocean area in the arctic has also decreased from 1970s to 1990s. Greenland ice sheet (world's second largest land-bound ice) lost about 8.3 km^3 of ice each year between 1993–98. Mountain glaciers around the world are melting at an accelerating rate. Qori Kalis glacier (largest glacier in Peruvian Andes) and Gangotri glacier (in India) are decreasing by about 30.5 m or 100 ft a year. In addition to sea level rise by melting of glaciers and polar ice, thermal expansion of the warming ocean is also raising sea level. It is estimated that during 20th century, the sea level has risen by about 18 cm and most of this rise has been attributed to thermal expansion. It is further estimated by IPCC (U.N. Intergovernmental panel on climate change) that sea level will rise additional 50 cm by 2100 and this rise in sea level would flood low-lying coastal areas like Southern Louisiana and South Florida. Small island nations like Maldives in Indian ocean are considered highly vulnerable to sea level rise (80% of Maldives is lower than 1 m above sea level). Some other vulnerable countries to sea level rise are Bangladesh, Egypt, Vietnam, Mozambique, etc. Besides permafrost (permanently frozen subsoil of tundra and taiga forests) is also melting. This permafrost acts as foundation for tundra plants and forest trees as well as houses and roads. Due to melting of permafrost by global warming, hundreds of homes and telephone poles are sinking into ground in Alaska.

Ozone layer depletion : Stratosphere zone of earth's atmosphere contains a layer of ozone (O_3) which prevents the earth surface from about 99% of incoming solar UV-radiations. UV-radiations are divided into 3 bands:

(a) UV-A (having wavelengths 320–400 nm)
(b) UV-B (having wavelengths 280–320 nm)
(c) UV-C (having wavelengths 200–280 nm)

- UV-C, having shorter wavelength is more energetic and thus **more dangerous** (or the most lethal wavelengths). Ozone in the atmosphere absorbs all incoming UV-C and most of UV-B radiations. UV-A is not affected by ozone.

A slight thinning of ozone layer occurs naturally for a few months every year over Antarctica. The maximum thinning occurs in September every year and it is commonly called **'ozone hole'** (ozone level decreases by as much as 67% every year). During 1990s the ozone hole continued to grow and in 1998, it became maximum (having record size of 27.5 million km^3). However, in 1999, the ozone hole was slightly smaller, *i.e.*, 25 million km^3. Slight thinning in ozone layer has also been observed over the Arctic.

- World levels of stratospheric O_3 have been decreasing for several decades and ozone levels over Europe and North America have decreased by about 10% since 1970 (Stratospheric O_3 is measured in Dobson units).
- The primary chemicals responsible for ozone depletion are a groups of chlorine containing compounds called **chlorofluorocarbons (CFCs)**, used as coolants in air conditioners and refrigerators (Freon) and propellants for aerosol cans and foam blowing agents for insulation and packaging and also as solvents. Besides halons, methyl bromide, methyl chloroform, carbon tetrachloride and nitrous oxide are also responsible for O_3 loss.

○ (Sherwood Rowland, Mario Molina and Paul Crutzen first explained association between thinning O_3 layer and CFCs and got Nobel prize in chemistry 1995).

- After their release into troposphere, CFCs and other chlorine containing compounds go to stratosphere where these are broken down by UV-radiations releasing chlorine. Similarly, bromine is released by breakdown of halons and methyl bromide. The sunlight catalyzes the chemical reaction by which chlorine or bromine break O_3 molecules and convert them into O_2 molecules. This chemical reaction does not change chlorine or bromine and thus single chlorine or bromine atom can breakdown many thousands of O_3 molecules. The chlorine and bromine remain in stratosphere for many years (one chlorine atom destroys upto 1,00,000 molecules of O_3).

Due to depletion of O_3 layer, higher levels of UV-rays reach to earth's surface, which cause many health problems in humans such as **eye cataracts, skin-cancer and less immunity.** About 2.2 million cases of skin cancers occur every year in world. UV-B radiations cause mutation in DNA of skin cells. Further increased levels of UV-radiations disrupt ecosystems as UV-radiations check photosynthesis in phytoplanktons.

Acid rains : The main precursors of acid rain are SO_2 and NO_2 in atmosphere, which form H_2SO_4 (sulphuric acid) and HNO_3 (nitric acid) with H_2O and these come down with rain. Such rains are called **acid rains,** which cause harm to both plants and animals. Ingredients of acid rain are 65% H_2SO_4, 30% HNO_3 and 5% HCl.

- Lichens and mosses are the main indicators of air pollution and thus act as **indices of atmospheric purity** (IAP).
- Major air pollution disaster in India occurred on December 3, 1984 at Bhopal due to release of **MIC** (methyl isocyanate gas) from insecticide (SAVIN) factory of union carbide. This caused death of over 2,000 people.
- Dust particles in different industries cause lung fibrosis or **pneumoconiosis** (including silicosis, asbestosis, siderosis, etc).

2. Water pollution

Water pollution is mainly caused by industrial wastes, sewage (house hold waste), insecticides, herbicides, rodenticides, etc.

- Strength of sewage or degree of water pollution is measured in terms of **BOD** (Biochemical oxygen demand) value. BOD may be defined as, 'number of miligrams of O_2 required for decomposition of one litre of waste or water by decomposing micro-organisms (bacteria)'.
- If BOD is less than 1500 mg/litre, it indicates weak sewage or less pollution.
- If BOD is 1500–4000 mg/litre, it indicates medium sewage or medium pollution.

- If BOD is more than 4000 mg/litre, it indicates strong sewage or high pollution.

Herbicides (*e.g.*, 2, 4-D, 2, 4, 5-T), **insecticides** (*e.g.*, DDT, aldrin, BHC) and **rodenticides** are also cause of water pollution.

- DDT is non biodegradable pollutant and its **biological magnification** occurs, *i.e.*, its concentration goes on increasing with each trophic level. Further it causes air, water and soil pollution.

  The concentration of DDT and aldrin, etc, has increased very much in our flesh and it is causing various types of health problems.

  Several **industrial effluents** like acids, alkalies, fluorides, phenols, heavy metals like mercury, cadmium, lead, zinc, copper, cobalt, etc., also pass into water bodies and cause water pollution.

- Mercury (Hg) is very persistent effluent. Higher concentration of Hg causes a serious disease called **Minamata** disease after the name of town Minimata of Japan, where it was first reported in 1952.
- Cadmium (Cd) accumulation in liver, kidneys and thyroid causes **itai-itai** (ouch-ouch) disease.

3. Soil pollution

Alteration in soil brought about by different types of wastes, constitute **soil pollution**. The chief wastes which cause soil pollution are agricultural, industrial, urban and radioactive wastes. Besides biological pathogens play role in soil pollution.

Toxicity of soil increases as a result of these wastes, which has adverse effect on human beings.

- Excessive use of nitrogen fertilizers has increased levels of nitrates in soil, which is responsible for **'blue baby syndrome'**. From soil, these nitrates go to leaves and fruits and then to human beings. In alimentary canal, bacteria convert nitrates into toxic nitrites, which combine with haemoglobin of blood to form **met-haemoglobin** due to which oxygen transport is reduced.

4. Noise pollution

Unwanted sound is called noise and it is measured in terms of decibels (dB).

- Audible sound is having intensity of 0 dB. Scooters, cars, etc., have intensity of sound upto 60 dB. Aeroplanes, etc., have intensity of sound as 80-100 dB, whereas jetaeroplanes have intensity of 120 dB.
- Generally sound above **80 dB** is termed as noise.
- Kanpur is the most noise polluted city in U.P.

Adverse effects of noise-pollution are:

(i) Nervousness.
(ii) High blood pressure.
(iii) Short temperness.
(iv) Loss of hearing capacity.
(v) Constriction of stomach muscles, which stops the proper functioning of muscles and hence leads to indigestion problems.
(vi) Liver stops functioning.
(vii) Dilation of pupil and paling of skin.
(viii) Nausea, giddiness, epilepsy and peptic ulcers.

- Large green plants are planted in high noise pollution zones because they have capacity to absorb sound waves and these green plants for checking noise pollution are known as **'green muffler'**.

5. Radioactive pollution

Ultimate hazard to mankind is **radioactive pollution** or **radioactivity**.

- Chief source of radioactive pollution is **nuclear-explosions**. These nuclear explosions release long-lived and short-lived radioactive substances, *e.g.*, Sr^{90}, Cs^{137}, C^{14}, CO^{60}, Ru^{106}, etc. These radioactive substances are initially in gaseous form 10–15 km above earth's surface. Then these condense to form liquid and then change into **solid dust**, which form **radioactive-clouds** and then these come down along with rain.
- These radioactive fallouts or nuclear fallouts cause **air, water and soil pollution.**
- Most important long lived radioactive substance released in nuclear explosions is Sr^{90}, which accumulate in bone-marrow and cause cancer (leukemia or blood cancer), genetic disorders and other deformities. Cs^{137} accumulates in muscles and causes muscular pain.
- In case of nuclear war, it is estimated that protective ozone layer will be destroyed by about 70% and there will be complete darkness at noon as a result of radioactive dust cloud and further global temperature will be greatly reduced (**Nuclear winter**).
- Radioactive disasters occurred first in 1945 in Hiroshima and Nagasaki cities of Japan, when USA dropped nuclear bombs during world war II.
- Recently on April 26, 1986, nuclear accident occurred at Chernobyl (USSR).

6. Thermal pollution

Due to nuclear and other conventional sources, temperature of water bodies and atmosphere increases, which has adverse effect on different organisms.

Control of pollution

1. By providing education to masses.

2. Air pollution can be controlled by use of **electrostatic precipitators** and **spray collectors** or **scrubbers**. Here different liquids are sprayed on gases coming out of industries and dissolve some harmful gases.

- For controlling air pollution, automobiles are nowadays being fitted with **catalytic converters**, which convert CO and harmful hydrocarbons into CO_2 and water vapours.

3. For control of sewage pollution or water pollution, **sewage oxidation ponds** or filter-beds or septic tanks or decomposition ponds have been developed by CPHERI (Central Public Health Engineering Research Institute, Nagpur). These oxidation ponds have luxuriant growth of **algae and bacteria.** Algae release O_2 and aerobic bacteria break down sewage using this O_2.

4. By growing large number of trees along road-sides and around industries.

5. Complete ban on all nuclear tests and further radioactive effluents or royal wastes should be disposed off with great precaution.

NATURAL RESOURCES

Natural resources are those living and non-living components of environment or nature which are being drawn and can be drawn for supporting life and meeting requirements of human beings.

Natural resources are mainly of 2 types:

(A) Inexhaustible resources

These are natural resources which are found in much abundance and cannot be exhausted or diminished, *e.g.*, air, sand, clay, solar energy, tidal energy, etc., however their quality may change as a result of pollution.

(B) Exhaustible resources

These are natural-resources which are likely to be exhausted or diminished as a result of their continuous use. These are further of 2 types:

(a) **Renewable resources** are those which can be again generated or produced artificially or naturally, *e.g.*, forest, water, natural pastures, marine resources and animal resources, etc.

(b) **Non-renewable resources** are those which cannot be again produced or generated, *e.g.*, fossil fuels (coal, petroleum products, lignite, natural gas), minerals, etc.

BIODIVERSITY

In broad sense, biodiversity is synonym for 'life on earth' or biodiversity is the totality of genes, the species, the ecosystems in a given region of the world.

As per Article 2 of the International convention on biodiversity formulated during the **Earth summit** of UNCED (United Nations Conference on Biological Diversity) in June 1992, biodiversity is defined as, **'Variability among the living organisms from all sources including inter alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are the part; this includes diversity within species, between species and of the ecosystems.'**

Life on Earth is still largely unexplored at the species and intraspecific level and hence total knowledge of world flora and fauna is unavailable. The total number of biological species on earth is estimated to be 13–14 million but only 2 million species have been scientifically described.

- India's biodiversity is one of the most important in the world and India is one of the twelve mega-biodiversity centres of the world because it has rich diversity of biological resources. There are nearly 45,000 plant species representing 7 per cent of the world's flora. Nearly 4,900 species of flowering plants are endemic to India. Further over 81,000 species of animals have been recorded from India which represent 6.4% of the world's flora. Besides 14 different types of climatic forests covering 6,50,000 sq. km are present in India.

Benefits from biodiversity: Biodiversity provides numerous direct and indirect services to human beings, *e.g.*,

(i) Diversity of plants and animals provide a vast variety of foods and fabrics.

(ii) Biodiversity enriches the lives of people in industrialized world and developing countries provides the means of survival to people in developing countries.

(iii) Preserving biodiversity provides **economic benefits** which include improving the desirable characteristics of crops, making plants more pest resistant, providing medicines to treat and curve illness, supporting ecotourism and providing enjoyment to individuals.

(iv) Maintenance of ecological balance or ecosystem stability.

Threats to biodiversity: The loss of biodiversity is a global crisis and there is hardly any region on earth that is not facing ecological catastrophes. Biological extinction has been a natural phenomenon in geological history but man's intervention or interference has speeded up extinction rates. If this trend of depletion continues, one quarter of world's species may be gone by the year 2050. Harward entomologist **E.O.** Wilson estimates that 20,000 species are being pushed into extinction every year. Since, 90% of all known species are tropical, hence the greatest losses are in this group.

Main threats to biodiversity are:

(i) Habitat destruction, *i.e.*, destruction of tropical forests, wetlands and other biologically rich ecosystems around the world.

(ii) Hunting and fishing.

(iii) Selective destruction.

(iv) Desertification.

(v) Biological invasion or introduction of exotic species which by removal of biological control cause ecological imbalance.

(vi) Shifting cultivation.

(vii) Hot spots (species rich threatened areas). India has 2 of 18 identified hot spots in world namely Western ghats and North-East Himalayas.

(viii) Pollution.

(ix) Global climatic changes.

(x) High population.

(xi) Industrial agriculture.

(xii) Economic system and policies that fail to value environment.

(xiii) Deficism in knowledge and its application.

Threatened species

Those species which are likely to become extinct if proper measures are not taken to protect them. IUCN (International Union for Conservation of Nature and Natural Resources), with its headquarters at Morges in Switzerland, recognizes following categories of threatened species:

1. **Endangered species (E) :** Those species whose survival is unlikely if the causal factors continue to act or species facing extinction are called Endangered species. 25,000 species of plants are estimated to face extinction today, *i.e.*, Endangered.

2. **Vulnerable species (V) :** Those species which are likely to fall into category of endangered in near future if causal factors continue to act, are called vulnerable species.

3. **Rare species (R) :** The species with small world population which are at risk of becoming endangered or vulnerable, are called rare species.

4. **Intermediate species (I) :** The species suspected to belong to either of above three categories but the reason is not known.

Red data book : IUCN maintains a red data book, in which list of endangered species of plants and animals has been given. This book has **pink pages** for critically endagered species.

- In red data book, prepared by DOE, government of India, **435 species of endangered plants** have been listed.

Some of the common endangered species of plants are as follows:

(A) Endangered ornamental plant species

Aerides crispum (Orchidaceae), *Cymbidium macrorhiza* (Orchidaceae), *Rhododendron edgeworthii* (Ericaceae).

(B) Endangered medicinal plant species

Atropa acuminata (Solanaceae), *Podophyllum hexandrum* (Podophyllaceae), *Rauwolfia serpentina* (Apocynaceae), *Saussurea lappa* (Asteraceae).

(C) Endangered scientific value plant species

Balanophora involucrata (Balanophoraceae), *Dischidia benghalensis* (Asclepiadaceae), *Nepenthes khasiana* (Nepenthaceae), *Sapria himalayensis* (Rafflessiaceae), *Tetracentron sinense* (Tetracentraceae).

(D) Endangered plant species of economic importance

Dioscorea **sps. (Dioscoreaceae) :** An important source of steroids, ***Pinus gerardiana*** (Gymnosperm) —Seeds source of chilgoza, ***Santalum album*** (Santalaceae)—Source of chandan, etc.

Conservation of biodiversity

1. Establishment of National Parks, Sanctuary or Biosphere reserves, where there is no danger of hunters or poachers (*In situ* conservation or on site conservation or conservation within their ecosystem or natural habitat):

(a) **National parks :** These are government maintained protected areas or reserves, where biodiversity is protected from any kind of exploitation, *i.e.*, cultivation, grazing, hunting, etc., are not allowed.

(b) **Sanctuaries :** These are the areas where hunting is not allowed but other activities like cultivation, grazing, collection of forest products, etc., are allowed.

(c) **Biosphere reserves :** These are multipurpose protected areas of different representative ecosystems which are meant for conservation of biodiversity or wild-life, traditional life style of tribals and their domesticated animals and also plant resources. Each biosphere reserve has a core zone (where no human activity is allowed), a **buffer zone** (with limited human activity) and **manipulation zone** (where human activity is allowed without degradation of ecology).

2. By allowing the species to grow in zoos, gardens, etc. (*Ex situ* conservation or off site conservation or conservation of biological diversity outside their natural habitat).

3. Establishment of gene banks.

4. Legislation and awareness.

5. Control of over-exploitation.

6. Control of plant introductions or control of exotic species so that they are not able to disturb the local ecosystem.

- *In situ* conservation of plants is costly to maintain and susceptible to natural calamities and other damages. Biotechnological methods (like *in vitro* propagation, slow growth and cryopreservation procedures) for conservation of plant resources have been developed in past two decades.
- India has one of the largest networks of protected areas in the world, *i.e.*, having 553 national parks and sanctuaries providing *in situ* or onsite conservation. 14 biodiversity rich areas have been designated as biosphere reserves to conserve respective ecosystems. Further 5 of the protected areas have been designated as **world heritage sites** under UNESCO'S World Heritage program. Two gene sanctuaries for citrus and orchids have been established in the areas of their diverstiy. National gene bank located at NBPGR, New Delhi has a capacity for long term storage of over million accessions. Further, a **'plant biodiversity garden'** has been established at NBPGR on August 7, 2000.

National and International efforts for conservation of biodiversity : Considerable harm has been done and is being done to wild-life and biological resources. Slowly we are adopting international treaties and national legislation to protect over biodiversity. Parks, wild-life refuges, nature preserves, zoos and restoration programs have been established to protect nature.

In 1975, Convention on International Trade in Endangered species (CITES) was a significant step towards world wide protection of endangered flora and fauna. It regulated trade in living specimens and products derived from listed species. The conservation of biodiversity has received an impetus as a consequence of the coming in force of the convention on Biological Diversity in December 1993. The convention, which was signed by majority of the nations during the UNCED Earth Summit held in Rio de-Janeiro in June 1992— is now an international law. India ratified the convention in February 1994. This convention through recognizing sovereign rights of nations over their biodiversity, cells for facilitation of access to genetic resources on 'mutually agreed terms' and with prior informed consent of the country providing these, with a commitment on recipient country to share in the benefits of utilising the resources thus provided.

- In India, several measures have been adopted to conserve and sustainably utilize the biological resources such as legal and policy frame work, *in situ* and *ex situ* conservation efforts, research and training, education and awareness. Botanical Survey of India (BSI) was established in 1890 and Zoological Survey of India (ZSI) was established in 1916 to undertake survey and to invent floral and faunal resources. The Forest Survey of India (FSI) was established in 1981 to assess the Forest wealth and to develop an accurate data base for planning and monitoring.
- Wild-life protection act was passed in 1972, under which national parks and sanctuaries have been created.
- For conservation of forest biodiversity, new forest policy has been formulated in 1988, which clearly states that management of forest resources in India needs active participation of the local people in order to save its biodiversity.
- Social forestry programme was started in 1976 to protect the forest degradation. Similarly, Agroforestry and urban forestry programmes have also been started.
- Some voluntary organizations have also started movements for conservation of biodiversity, *e.g.*, **Chipko movement** in 1972 in Tehri-Garhwal of U.P. (Now in Uttaranchal) under leadership of Shri Sunder Lal Bahuguna; **Appiko movement** in south under leadership of Pandurang Hegde.

ZONATION IN A FRESH WATER BODY (LAKE)

Large fresh water bodies constitute lakes. On the basis of productivity lakes are of two types:

1. Eutrophic lakes

The lakes **rich in nutrients** are called eutrophic lakes.

2. Oligotrophic lakes

The lakes **poor in nutrients** are called oligotrophic lakes.

- Deep lakes show **photic** as well as **thermal** zonation.
- On the basis of light (photic) zonation, the shallow water banks constitute **littoral zone.** The open water zone to the depth to which light can penetrate is called **limnetic zone.** The deep water area or deep water parts, where light cannot penetrate, is called **profundal** or **aphotic zone.** Generally aphotic zone is absent in ponds and lakes. (Fig. 26.11)
- On the basis of temperature strata, again three zones are there, *i.e.*, **epilimnion,** upper stratum which is exposed to sun-rays. It is warmer during summer and comparatively cooler during winter. **Hypolimnion** is the basal stratum where water is always cool. **Metalimnion** is the zone of transition between epilimnion and hypolimnion. (Fig. 26.12)

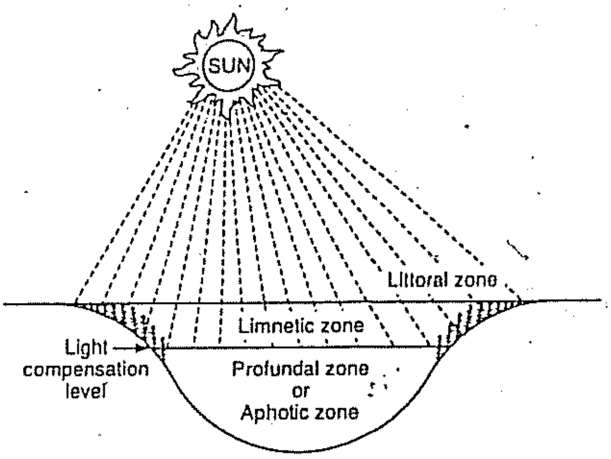


Fig. 26.11. Photic zonation of a fresh water body

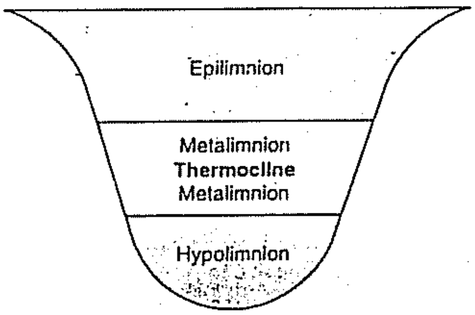


Fig. 26.12. Thermal zonation of a fresh water body

- The maximum temperature change occurs in the middle portion of metalimnion, which is called **thermocline** (short zone in water body where there is sharp fall in temperature).
- Transparency or turbidity of water is measured by an instrument called **secchi disc.**

Some other important points to remember

- An instrument used for measuring height of the forest or trees is called **hypsometer.**
- **Silent valley** which contains rare species of plants and animals is in **Kerala.**
- World environment day—**5th June.**
- World Earth day—**22nd April.**
- International ozone day—**16th September.**
- World population day—**11th July.**

Sciophytes - shade loving?

MULTIPLE CHOICE QUESTIONS

1. Who used the term 'Ecology' for the first time in literature?
(a) Thoreau (b) Hillaire
[✓ (c) Reiter] (d) Warming

2. Who started ecological studies in India?
(a) Saxton (b) Dudgeon
(c) R. Mishra (d) Agharkar

3. Species content of a region irrespective of numerical strength of each species is called:
(a) Vegetation [✓ (b) Flora]
(c) Community (d) None of these

4. Zone of transition, presenting a situation of special ecological interest between two types of communities is called as:
(a) Ecad (b) Ecotype
[✓ (c) Ecotone] (d) None of these

5. Organisms that occupy the similar ecological niches in the different geographical regions are:
(a) Ecological amplitude (b) Ecotone
[✓ (c) Ecological equivalents] (d) None of these

6. Limnology is:
(a) Marine ecology (b) Estuarine ecology
[✓ (c) Fresh water ecology] (d) None of these

7. The plants which grow best in sun but can also grow fairly well under shade:
(a) Heliophytes (b) Sciophytes
(c) Facultative sciophytes [✓ (d) Facultative heliophytes]

8. The highest value of temperature that can be tolerated by a particular metabolic process without injury is:
(a) Minimum [✓ (b) Maximum]
(c) Optimum (d) None of these

9. The injury of plants of hot climate, when exposed to low temperature for sometime is:
[✓ (a) Chilling injury] (b) Freezing injury
(c) Desiccation (d) None of these

10. Hekistotherms are plants growing at:
(a) Low temperature (b) High temperature
[✓ (c) Very low temperature] (d) Very low light.

11. Which matters much as ecological factor?
[✓ (a) Relative humidity] (b) Absolute humidity
(c) Both (a) and (b) (d) None of these

12. The protoplasmic adaptation that affords immunity to low temperature injury is called:
(a) Lodging [✓ (b) Hardening]
(c) Logging (d) Freezing

13. Hypersaline water is found in:
(a) Temperate lakes (b) Tropical lakes
(c) Estuary (d) All of these

14. Secchi-disc is used to measure:
(a) Temperature (b) Light intensity
[✓ (c) Turbidity of water] (d) Wind velocity

15. Psychrometer is used in measuring:
(a) Light [✓ (b) Relative humidity]
(c) Temperature (d) None of these

16. Soil moisture is measured by:
(a) Psychrometer (b) Lux-meter
(c) Anemometer [✓ (d) Tensiometer]

17. The soil with particle size between 0·002 – 0·02 mm is:
(a) Clay (b) Fine sand
[✓ (c) Silt] (d) Coarse sand

18. The plants growing in cold soils are:
(a) Oxylophytes [✓ (b) Pychrophytes]
(c) Halophytes (d) Chasmophytes

*19. Therophytes are:
(a) Biennial plants [✓ (b) Seasonal plants]
(c) Perennial plants (d) None of these

*20. The concentration of CO_2 in atmosphere is:
(a) 30 ppm [✓ (b) 300 ppm]
(c) 3000 ppm (d) 3 ppm

21. When rainfall is more during winter and low during summer, then which types of plants grow?
(a) Evergreen (b) Sciophytes
(c) Grasses [✓ (d) Sclerophyllous plants]

22. 'Solonetz' is an international term for:
(a) Black alkaline soil (b) White alkaline soil
(c) Loam soil (d) Clay soil

23. CO_2 conc. in soil atmosphere as compared to air is:
[✓ (a) More] (b) Less
(c) Equal (d) Nil

24. Which water is available to plants?
(a) Gravitational [✓ (b) Capillary]
(c) Hygroscopic (d) Combined

25. Capillary water belongs to which category of soil water?
(a) Chresard (b) Echard
(c) Both (a) and (b) (d) None of these

26. pH values of natural soils range from:
(a) 2–8.0 [✓ (b) 3.0–8.5]
(c) 4.0 – 9.5 (d) None of these

27. Fertile soil has pH around:
(a) 5–6 [✓ (b) 6–7]
(c) 8–9 (d) 4–5

28. Organic matter fallen recently to the ground is called:
[✓ (a) Litter] (b) Duff
(c) Peat (d) Humus

29. The soil transported by water is:
(a) Colluvial [✓ (b) Alluvial]
(c) Eolian (d) Glacial

30. When in an association, only one species is benefitted and neither is harmed: **(AFMC 2000, 2001; Kerala PMT 2002)**
(a) Mutualism (b) Proto-cooperation
[✓ (c) Commensalism] (d) Exploitation

31. Mycorrhiza is an example of: (CBSE 2003)
    [✓ (a) Mutualism] (b) Commensalism
    (c) Parasitism (d) Exploitation
32. The vascular plants rooted in the soil and perched on other plants for support are called:
    (a) Epiphytes [✓ (b) Lianas]
    (c) Predaceous plants (d) Parasites
33. Carnivorous plants are examples of:
    (a) Parasitism [✓ (b) Predation]
    (c) Commensalism (d) None of these
34. *Rafflesia* is a parasite:
    [✓ (a) Total root] (b) Total stem
    (c) Partial root (d) Partial stem
35. *Rafflesia* is found on roots of:
    [✓ (a) *Vitis*] (b) *Santalum*
    (c) *Cycas* (d) None of these
36. The complete or partial inhibition of one micro-organism by another through production of some metabolic substances is called:
    [✓ (a) Allelopathy] (b) Antagonism
    [✓ (c) Antibiosis] (d) None of these
37. Solubility and availability of plant nutrients are related to:
    (a) Soil pH (b) Soil porosity
    (c) Soil temperature [✓ (d) All of these]
38. Laterite soil is rich in:
    (a) Ca (b) Mg
    [✓ (c) Fe] (d) Cu
39. Most favoured habitat of plants is named as:
    (a) Ecological system (b) Ecological habitat
    (c) Ecological type [✓ (d) Ecological niche]
40. UV-radiations from sunlight causes the reaction that produces:
    (a) CO (b) SO_2
    [✓ (c) O_3] (d) Fluorides
41. Grasslands with scattered trees are called: (MPPMT 2002)
    (a) Rain forests (b) Evergreen forests
    [✓ (c) Savannah] (d) Deciduous forests
42. Edaphic factors are related to:
    (a) Man (b) Animals
    [✓ (c) Soil] (d) Temperature
43. 'Water logging' occurs in:
    [✓ (a) Clay soil] (b) Loamy gravel
    (c) Sandy soil (d) Gravel soil
44. Myrmecophilly is a beneficial association between some flowering plants and:
    (a) Bacteria (b) Virus
    [✓ (c) Ants] (d) Mycoplasma
45. 'MAB' stands for: (CBSE 1997)
    (a) Man, antibiotic and bacteria
    (b) Man and biotic community
    (c) Man and biosphere
    (d) Meyer, Anderson and Bisby
46. Soil particles in order of increasing size are:
    (a) Gravel, clay, sand and silt
    (b) Sand, silt, clay, gravel
    (c) Clay, silt, sand, gravel
    (d) Silt, clay, sand, gravel
47. Rhododendrons are characteristic plants of:
    (a) Coniferous vegetation [✓ (b) Alpine vegetation]
    (c) Tropical vegetation (d) None of these
48. Autumn colouration of leaves appears only in:
    (a) Tropical plants
    (b) Evergreen plants
    [✓ (c) Temperate deciduous plants]
    (d) Desert plants
49. Endemic plants are those which are:
    (a) Of wide distribution
    [✓ (b) Restricted to a certain area]
    (c) In Arctic regions
    (d) None of the above
50. Competition is most severe in:
    [✓ (a) Closely related species growing in the same area]
    (b) Closely related species growing in different habitat
    (c) Distantly related species growing in the same habitat
    (d) Distantly related species growing in the different habitat
51. Ecades of a species are genetically: [illegible]
    [✓ (a) Similar]
    (b) Different
    (c) Sometimes similar, sometimes different [illegible]
    (d) None of the above
52. If ecotypes are grown in similar environmental conditions, they will be:
    (a) Similar [✓ (b) Different]
    (c) Similar or different (d) None of these
53. One inch of soil formation takes:
    (a) 100–500 years [✓ (b) 500–1000 years]
    (c) 100–200 years (d) 10–50 years
54. Fully decomposed organic matter (humus) occurs in which horizon of soil profile? (CPMT 2003)
    [✓ (a) A-horizon] (b) B-horizon
    (c) C-horizon (d) R-horizon
55. The type of soils found in temperate humid regions:
    (a) Laterite [✓ (b) Podsols]
    (c) Gleys (d) None of these
56. Which of the slope shows luxuriant vegetation?
    [✓ (a) Northern slope] (b) Southern slope
    (c) Both (a) and (b) (d) None of these
57. Row of tall trees for preventing wind action is:
    (a) Wind fall [✓ (b) Wind breaks]
    (c) Wind cheater (d) Wind throw
58. The total interacting animals and plants in any well defined area is known as:
    (a) Biosphere (b) Biome
    [✓ (c) Community] (d) Ecosystem
59. Good soil is:
    (a) Which holds whole of the water that enters into it
    [✓ (b) Which allows to percolate the water slowly from it]
    (c) Which allows water to pass very quickly from it
    (d) Which allows limited amount of water into it

علی فوٹو کاپی
[illegible]

60. The circulation or cycling of elements in an ecosystem is known as: **(MPPMT 1992, 99)**
(a) Geological cycling
(b) Geochemical cycling
(c) Biogeochemical cycling
(d) Chemical cycling

61. Plants growing in rock crevices:
(a) Lithophytes (b) Eremophytes
(c) Chasmophytes (d) Psammophytes

*62. Epiphytes obtain water from:
(a) Ocean (b) Host
(c) Soil (d) Atmospheric environment

63. Ecological niche of an organism is:
(a) Way of life (b) Foraging area
(c) Habitat (d) Defended territory

64. Species that occur in different geographical regions separated by spatial barrier are:
(a) Autogenic (b) Allogenic
(c) Allopatric (d) Sympatric

65. When is a man part of biotic community?
(a) Only when he lives in big cities
(b) Always
(c) Only when he lives in forests
(d) Never

66. Maintenance of soil fertility without addition of nutrients is due to: **(AFMC 2001)**
(a) Crop residue
(b) Activity of micro-organisms
(c) Floods
(d) Favourable temperature

67. Ecological niche is normally occupied by:
(a) A population (b) A small community
(c) Competing species (d) Competing genera

68. Water covers what percentage of earth's surface?
[✓ (a) 73] (b) 83
(c) 63 (d) None of these

69. The term 'Niche' was first used by: **(CET Chandigarh 1997)**
(a) Clements [✓ (b) Grinnel]
(c) Warming (d) Odum

70. 'Symbiosis' term was proposed by:
(a) Haskell (b) De Bary
(c) Grinnel (d) Burkholder

71. 'Solonchak' is an international term for:
(a) Black alkaline soil (b) White alkaline soil
(c) Loam soil (d) None of these

72. Field capacity includes:
(a) Gravitational, capillary, hygroscopic water and water vapours
(b) Capillary, hygroscopic, combined water and water vapours
(c) Gravitational, hygroscopic, combined water and water vapours
(d) None of the above

73. When after wilting, plants do not come to its original position without giving additional water to soil is called:
(a) Incipient wilting (b) Temporary wilting
(c) Permanent wilting (d) None of these

74. The percentage of N_2 in atmosphere is:
(a) 75% (b)79%
(c) 89% (d) 69%

75. The chief source of nitrogen for plants in soil is:
(a) Nitrite [✓ (b) Nitrate]
(c) Free N_2 (d) Ammonia

76. Direct ecological factor is:
(a) Soil texture (b) Wind
(c) Temperature (d) Altitude

77. The instrument which measures wind velocity is:
(a) Potometer (b) Lactometer
(c) Hygrometer [✓ (d) Anemometer]

*78. Epiphytes are common where:
(a) O_2 concentration is high
[✓ (b) Rainfall throughout the year]
(c) Temperature is low
(d) Rainfall is seasonal

79. 'Physiological dryness' is faced by:
(a) Pond plants (b) Desert plants
[✓ (c) Bog plants] (d) Epiphytes

80. *Santalum* is a parasite:
(a) Total root (b) Total stem
(c) Partial root (d) Partial stem

81. Carnivorous plants catch the insects to fulfil their which requirement?
(a) O_2 (b) Sulphur
(c) Phosphorus [✓ (d) Nitrogen]

82. Which is a predacious fungi?
[✓ (a) *Arthrobotrys*] (b) *Rhizopus*
(c) *Pyronema* (d) *Polyporus*

83. Endotrophic mycorrhiza is found in:
(a) Pines (b) Oaks
[✓ (c) Orchids] (d) Beech

84. *Bauhinia* is an example of:
(a) Parasite (b) Epiphyte
[✓ (c) Lianas] (d) Predator

85. Ecology involving the structure, nature, organization and development of plant communities is known as:
(a) Autecology [✓ (b) Synecology]
(c) Phytosociology (d) Palaeoecology

86. Plants requiring low calcium or found in acidic soils:
(a) Calciphytes (b) Psammophytes
[✓ (c) Oxylophytes] (d) Halophytes

87. Ozone (O_3) is formed in which zone of atmosphere:
(a) Mesosphere [✓ (b) Stratosphere]
(c) Troposphere (d) Ionosphere

88. What is correct sequence of different zones of atmosphere from below?
[✓ (a) Troposphere, Stratosphere, Mesosphere, Ionosphere]
(b) Stratosphere, Troposphere, Ionosphere, Mesosphere

(c) Mesosphere, Stratosphere, Troposphere, Ionosphere
(d) Ionosphere, Mesosphere, Stratosphere, Troposphere

89. Earth's atmosphere is upto:
(a) 20 km (b) 200 km
[✓ (c) 300 km] (d) 90 km

90. Flattening of herbaceous plants against ground due to wind is:
(a) Logging [✓ (b) Lodging]
(c) Dwarfism (d) Abrasions

91. The plants which grow well under fire burnt conditions are:
(a) Chersophytes (b) Eremophytes
[✓ (c) Pyrophytes] (d) Cryophytes

92. Biogeocoenosis means:
(a) Ecology [✓ (b) Ecosystem]
(c) Community (d) Vegetation

93. Estuary is an example of:
(a) Ecotype [✓ (b) Ecotone]
(c) Ecophone (d) Ecades

94. What percentage of rain water is absorbed by ground?
(a) 45% [✓ (b) 20%]
(c) 35% (d) 40%

95. Lichens are:
[✓ (a) Hygrophytes] (b) Pyrophytes
(c) Therophytes (d) None of these

96. Palisade parenchyma is very well developed in leaves of:
[✓ (a) Heliophytes] (b) Sciophytes
(c) Both (a) and (b) (d) None of these

97. IBP stands for:
(a) Indian Biology Programme
[✓ (b) International Biological Programme]
(c) International Botanical Programme
(d) None of the above

98. Phytotron is a device in which: (CPMT 1997)
(a) Plants are collected
(b) Energy content of plants calculated
[✓ (c) Plants are cultivated under controlled conditions]
(d) None of the above

99. The term 'Oikologie' (ecology) was coined by:
(a) Hillaire [✓ (b) Haeckel]
(c) Reiter (d) Harvey

100. All living organisms on or around earth constitute:
(a) An ecosystem (b) A biosphere
(c) A community (d) A population

101. Amount of capillary water, which the soil can hold against force of gravity is:
(a) Storage capacity (b) Field capacity
[✓ (c) Gravitational water] (d) Hygroscopic water

102. Rhizosphere is denoted to soil which is:
(a) Subjected to the influence of plant root
(b) Attached to surface of root only
(c) Attached to surface of root hair only
(d) None of the above

103. Congress grass *(Parthenium argentatum)*, a troublesome weed produces an acid, which inhibits growth of other plants, is:
(a) HCN (b) Trans-cinnamic acid
(c) Oxalic acid (d) Indole acetic acid

104. Biotic potential refers to:
(a) Increase of population under optimum conditions
(b) Increase of population under given conditions
(c) Increase of population under natural conditions
(d) Increase of population under climatic conditions

105. Formation of sticky, compact, structureless layer at the bottom of B horizon and consequent accumulation of peat layer above it is known as:
(a) Gleization (b) Podsolization
(c) Laterization (d) Calcification

106. Process which involves decalcification and leaching of Fe and Al ores from A horizon:
(a) Gleization (b) Podsolization
(c) Lateralization (d) Calcification

107. Formation of upper calcareous layer of soil is:
(a) Gleization (b) Podsolization
[✓ (c) Lateralization] (d) Calcification

108. An interaction in which one population is inhibited, the other is not affected:
(a) Commensalism [✓ (b) Amensalism]
(c) Predation (d) Parasite

109. An interaction favourable to both populations, but no obligatory to either is:
(a) Mutualism (b) Proto-cooperation
(c) Commensalism (d) Parasite

110. Ecology which attempts to include all aspects of interaction of all organisms in a given area with both biotic and abiotic elements of their environment, is known as:
(a) Population ecology [✓ (b) Ecosystem ecology]
(c) Community ecology (d) None of these

111. 'Birds nest' epiphyte is:
(a) *Tortula* (b) Orchids
[✓ (c) *Asplenium*] (d) *Tsuga*

112. The term 'Ecological succession' was first used by:
(a) Tansley (b) Odum
[✓ (c) Hult] (d) Grinnel

113. Which is a common lianas in Indian tropical deciduous forests?
(a) *Dischidia* (b) *Bauhinia vauhillii*
(c) *Ficus elastica* (d) *Asplenium*

114. In which epiphyte, a pitcher like structure is formed for meeting water requirements?
(a) *Asplenium* [✓ (b) *Dischidia*]
(c) *Tortula* (d) Bromeliad

115. In many orchids with endotrophic mycorrhiza, the common fungus is:
(a) *Rhizopus* (b) *Fusarium*
[✓ (c) *Rhizoctonia*] (d) None of these

116. Flu gas is:
(a) Which causes flu
(b) Gaseous mixture coming out of automobiles
[✓ (c) Gases coming out of chimneys]
(d) None of the above

117. Most active centre of ecological studies in India is:
(a) Chennai (b) Delhi
(c) Allahabad (d) Varansi

118. Who is known as father of Indian ecology?
(a) R. Mishra (b) K.C. Mishra
(c) L.P. Mall (d) Pandeya

119. *Viscum* and *Loranthus* (partial stem parasite) live on stem of:
(a) Mango (b) *Vitis*
(c) Brinjal (d) None of these

120. Browzing is an example of:
(a) Parasitism (b) Predation
(c) Commensalism (d) None of these

*121. Total soluble salts in soil are measured by:
(a) Tensiometer (b) Conductivity meter
(c) pH meter (d) None of these

122. Zoochlorellae is an example of:
(a) Mutualism (b) Protacooperation
(c) Parasitism (d) Predation

123. The leaves (needles) of conifers have:
(a) High Ca content (b) Low Ca content
(c) High Fe contents (d) Low Fe contents

*124. Red soils in Orissa contain:
(a) High Mg (b) High Al
(c) High Fe (d) High Ca

125. National Institute of Oceanography has its headquarters at:
(a) Bombay (b) Delhi
(c) Dona Paula (d) Cochin

*126. If the CO_2 content of atmosphere is as high as 300 parts per million:
(a) All plants would be killed
(b) Plants would grow for sometime and then die
(c) Plants would not grow properly
(d) The plants would thrive well

127. Out of several gases present in the atmosphere, plants mostly depend:
(a) On concentration of O_2 for respiration
(b) On amount of N_2
(c) On CO_2 concentration
(d) On availability of CO

128. Vivipary may be described as:
(a) Germination of seed with cotyledons under the soil
(b) Germination of seed with cotyledons above the soil
(c) Development of seedling within an attached fruit
(d) Formation of fruit without pollination

129. Percentage of light energy utilized by plants for photosynthesis is:
(a) 100 (b) 50
(c) 10 (d) 4%

130. If all the green plants were to disappear from earth:
(a) The carnivores will continue to live
(b) Only birds and insects will die
(c) All the animals will die
(d) The chemasynthetic bacteria will produce food for all

131. The storage of energy at consumer's level is: **(MPPMT 2001)**
(a) Gross primary productivity
(b) Secondary productivity
(c) NPP
(d) Primary productivity

132. When a peacock eats snake which eats insects living on green plants, the peacock is?
(a) Primary consumer (b) Primary decomposer
(c) Primary producer (d) Apex of food pyramid

133. Technique of soil conservation by constructing plateform across the slopes is:
(a) Channel terracing (b) Basin listing
(c) Strip cropping (d) Bench terracing

134. A common soil binder plant in N.W. India is:
(a) *Dalbergia* (b) *Tectona*
(c) *Prosopis* (d) *Cassia*

135. Which plant is a halophyte?
(a) *Hydrilla* (b) Mango
(c) *Opuntia* (d) *Rhizophora*

136. Breathing roots are found in:
(a) Dry climate plants (b) Water plants
(c) Saline water plants (d) Normal climate plants

137. Root cap is absent in:
(a) Xerophytes (b) Mesophytes
(c) Hydrophytes (d) Halophytes

138. In submerged leaves of hydrophytes, respiration is through:
(a) Ventral surface (b) Dorsal surface
(c) General surface (d) None of these

139. Aerenchyma is found in or well developed in: **(CPMT 1999, 2001)**
(a) Mesophytes (b) Halophytes
(c) Xerophytes (d) Hydrophytes

140. Which xerophyte accumulates water in roots?
(a) *Opuntia* (b) *Asparagus*
(c) *Euphorbia* (d) None of these

141. An American plant which is a troublesome water weed in India is: **(CBSE 1993; AFMC 2000))**
(a) *Parthenium* (b) *Typha*
(c) *Trapa* (d) *Eichhornia*

142. Aquatic plants with floating leaves have: **(AFMC 2000)**
(a) Stomata on leaf surface
(b) Stomata on lower surface
(c) Stomata on upper surface
(d) No stomata

143. Sunken stomata are found in:
(a) Nerium (b) Mango
(c) Neem (d) None of these

144. Which is a correct sequence in a food chain?
(a) Grass → buffalo → deer → buffalo
(b) Bacteria → grass → rabbit → wolf
(c) Grass → insect → bird → snake
(d) Grass → snake → insect → deer

145. 'Van Mahotsav' was started by:
(a) K.M. Munshi (b) Sunder Lal Bahuguna
(c) Binova Bhave (d) J.L. Nehru

146. The earliest settlers on barren lands are:
(a) Diatoms (b) Lichens
(c) Mosses (d) Ferns

147. Biological equilibrium is an equilibrium between: [BCECE (P.T. Exam.) 2001]
(a) Producers
(b) Producers and consumers
(c) Decomposers and producers
(d) Producers, consumers and decomposers

148. Plant succession taking place in sandy area is:
(a) Halosere (b) Xerosere
(c) Lithosere (d) Psammosere

149. Term 'Ecosystem development' to ecological succession was given by:
(a) Odum (b) Clements
(c) R. Mishra (d) Blackmans

150. In an aqueous environment, microscopic plants and animals are collectively known as: (MPPMT 1999)
(a) Commensals (b) Herbivores
(c) Flora and fauna (d) Planktons

151. *Santalum* is naturally present in:
(a) Assam (b) Karnataka
(c) M.P. (d) Bihar

*152. Silent valley, which contains very rare species of plants and animals is in:
(a) Mumbai (b) Kerala
(c) Rajasthan (d) J & K

153. The maximum number of primary producers within a specified area would be in:
(a) Pond ecosystem (b) Grass land ecosystem
(c) Forest ecosystem (d) Desert

154. The environment provided by the wet leaf surface for microbial development is called:
(a) Rhizosphere (b) Rhizoplane
(c) Phyllosphere (d) Phylloplane

155. Which non-legume angiosperm contains root nodules?
(a) *Eucalyptus* (b) *Casuarina*
(c) *Amaranthus* (d) *Prunus*

156. NH_3 is converted into nitrates by activity of:
[✓ (a) Nitrifying bacteria] (b) Denitrifying bacteria
(c) Ammonifying bacteria (d) None of these

157. Which can fix atmospheric N_2?
(a) Rhodophyceae (b) Chlorophyceae
[✓ (c) Cyanophyceae] (d) None of these

158. The plants growing in cold soils are called:
(a) Oxylophytes [✓ (b) Psychrophytes]
(c) Halophytes (d) Chasmophytes

159. Plants growing in marsh are called:
(a) Halophytes (b) Helophytes
(c) Eremophytes (d) Psilophytes

160. Heterophilly is found in: (BHU 1999)
(a) *Nymphaea* (b) *Nelumbo*
(c) *Sagittaria* (d) *Vallisneria*

161. Specialized parenchymatous tissue consisting of thin-walled cells with enlarged intercellular cavities is termed as:
(a) Parenchyma (b) Prosenchyma
(c) Aerenchyma (d) Chlorenchyma

162. Vivipary is common in: (CMC Vellore 2003)
(a) Halophytes (b) Xerophytes
(c) Mesophytes (d) None of these

163. *Eichhornia* is a hydrophyte:
(a) Rooted submerged (b) Rooted floating
(c) Free floating (d) Rooted emergent

164. In submerged leaves, the mesophyll is:
(a) Highly differentiated (b) Poorly differentiated
(c) Undifferentiated (d) Not present

165. Those succulents in which leaves become fleshy are called:
(a) Sclerophyllous (b) Hygrophyllous
(c) Pyrophyllous (d) Malacophyllous

166. The true xerophytes or drought resistants are:
(a) Succulents (b) Non succulents
(c) Ephemerals (d) None of these

167. Shiny and glazed leaf surfaces are in:
(a) Hydrophytes (b) Halophytes
(c) Xerophytes (d) Mesophytes

168. When stem becomes fleshy, green and leaf like it is called:
(a) Phyllode (b) Cladode
(c) Phylloclade (d) None of these

169. The term 'Ecosystem' was given by: (MPPMT 2000, 2001; BHU 2002)
(a) Warming (b) Clements
(c) Tansley (d) Hillaire

170. Artificial ecosystem is:
(a) Pond (b) Forest
(c) Grassland (d) Cropland

171. The best picture of overall nature of ecosystem is given by:
(a) Pyramid of mass (b) Pyramid of number
(c) Pyramid of energy (d) None of these

172. Pyramid of biomass in pond ecosystem is:
(a) Always upright (b) Inverted
(c) Upright or inverted (d) None of these

173. Always upright shape of pyramid is in: (MPPMT 2001; CPMT 2001, 2002; CET Karnataka 2002)
(a) Mass pyramid (b) Energy pyramid
(c) Number pyramid (d) None of these

174. Rate of storage of organic matter in excess of respiratory utilization by plants is:
(a) Primary productivity
(b) Gross primary productivity
(c) Net primary productivity
(d) Secondary productivity

175. 'Tree hugging' movement is associated with:
(a) H.N. Bahuguna (b) S.L. Bahuguna
(c) Vinoba Bhave (d) None of these

176. Who is called 'Tree Saint' in India?
(a) Richard Barbe Baker (b) James Baker
(c) Sundar Lal Bahuguna (d) Clements

177. Annual weeds and short lived perennials like *Amaranthus, Chenopodium, Polygonum* are indicators of:
(a) Fire (b) Petrol deposits
(c) Overgrazing (d) Pollution

178. Succession beginning in saline soils is:
(a) Xerosere (b) Lithosere
(c) Psammosere (d) Halosere

179. Main air pollutant released by automobiles is:
(a) SO_2 (b) NO_x
(c) O_3 (d) PAN

180. Burning of coal produces pollution:
(a) NO_2 (b) SO_2
(c) O_3 (d) None of these

181. Development of bare area without any form of life, in succession is called:
(a) Nudation (b) Invasion
(c) Coaction (d) None of these

182. Sheet erosion is caused by: **(CPMT 1990)**
(a) Wind (b) Heavy rains
(c) Snow (d) Gravity

183. Major pollution causing agent is:
(a) Man (b) Animals
(c) Hydrocarbons (d) None of these

184. Ultimate environmental hazard to mankind is:
(a) Air pollution (b) Water pollution
(c) Noise pollution (d) Nuclear pollution

185. Mangrove vegetation is found in:
(a) Shimla valley (b) Western ghats
(c) Kullu valley (d) Sunderbans

186. The 'Acid rain' destroys vegetation because it contains:
(a) Sulphurous acid (b) O_3
(c) Nitrates (d) CO

187. Which is characteristic component of 'mangrove vegetation'?
(a) *Ficus religiosa* (b) *Rhizophora mangi*
(c) *Mangifera indica* (d) *Prosopis juliflora*

188. Which pollutant is not produced by automobiles exhaust?
(a) SO_2 (b) Flyash
(c) Hydrocarbons (d) CO

189. Grazing animals change vegetation by:
(a) Selective feeding (b) Cross pollination
(c) Seed dispersal (d) Spreading disease

190. Pyramid of energy in grassland ecosystem is:
(a) Upright (b) Inverted
(c) Both (a) and (b) (d) None of these

191. Lichens and mosses are observed in:
(a) Hydrosere (b) Xerosere
(c) Hydrarch succession (d) Psammosere

192. Radiation is a health hazard because it causes:
(a) Haemophilia (b) Leukemia
(c) Pneumonia (d) Polio

193. Physiological dryness is faced by :
(a) Pond plants (b) Desert plants
(c) Bog plant (d) Epiphytes

194. The main effect of SO_2 on plants is :
(a) Chlorophyll destruction (b) Plasmolysis
(c) Golgi body destruction (d) None of these

195. DDT is a: **(BCECE 2002)**
(a) Biodegradable pollutant
(b) Non-biodegradable pollutant
(c) Antibiotic
(d) None of the above

196. In a food chain, herbivores are: **(MPPMT 2000)**
(a) Primary consumers (b) Primary producers
(c) Secondary consumers (d) Decomposers

197. BOD stands for: **(PMET Punjab 2003)**
(a) Biotic O_2 demand (b) Biochemical O_2 demand
(c) Biosphere O_2 demand (d) None of these

198. Last stabilized community in plant succession is called:
(a) Ecosere (b) Climax community
(c) Seral community (d) Ecotone

199. Which is the best source of renewable energy?
(a) Coal (b) Petroleum
(c) Trees (d) Cattle

200. Detritious food chain starts from:
(a) Green plants (b) Dead organic matter
(c) Both (a) and (b) (d) None of these

201. Forests occupy what percentage of total land area in India?
(a) 40% (b) 22.8%
(c) 10% (d) 30%

202. Oceans occupy what percentage of earth's surface?
(a) 60% (b) 50%
(c) 75% (d) 80%

203. Maximum rate of productivity is of:
(a) Tropical grass land (b) Tropical forests
(c) Temperate forests (d) Croplands

204. Riparian erosion refers to:
(a) Wind erosion (b) Water erosion
(c) Gully formation (d) Stream bank erosion

205. Agrostological method of soil conservation is conservation by:
(a) Dry farming (b) Grasses
(c) Crops (d) None of these

206. Green house effect is due to increasing concentration of: **(MPPMT 2001)**
(a) CO_2 (b) CO
(c) SO_2 (d) O_3

207. Green house effect is leading to:
(a) Decrease in temperature
(b) Increase in temperature
(c) Maintaining the temperature
(d) None of the above

208. *Asparagus* is an example of :
(a) Phyllode (b) Phylloclade
(c) Cladode (d) None of these

209. The plants which grow in rock crevices are:
(a) Chersophytes (b) Chasmophytes
(c) Psilophytes (d) Eremophytes

210. *Darlingtonia* is a:
(a) Primary producer
(b) Primary consumer
(c) Primary producer and consumer
(d) Decomposer

211. Trophic levels are formed by: (AIIMS 2000)
(a) Organisms linked in food chains
(b) Only plants
(c) Only animals
(d) Only carnivores

212. The pollutants released by jetaeroplanes in the atmosphere as fluro-carbons are called:
(a) Photochemical oxidant (b) Photochemical reductant
(c) Aerosols (d) Smog

213. In a polluted lake, the index of pollution is:
(a) *Daphnia* (b) *Artemisia*
(c) Bacteria (d) Algae

214. Soil-erosion is greater when:
(a) No rain (b) Rain evenly distributed
(c) Wind blows (d) Rainfall heavy

215. On an average producers can store what percentage of radiant energy?
(a) 10% (b) 1%
(c) 20% (d) 50%

216. Desert plants are generally:
(a) Succulents (b) Heterophyllous
(c) Herbaceous (d) Viviparous

217. *Hydrilla* and *Vallisneria* are:
(a) Free floating hydrophytes
(b) Rooted emergent hydrophytes
(c) Rooted submerged hydrophytes
(d) Floating and anchored plants

218. Which of the following is a rich source of energy, but does not cause pollution?
(a) Solar energy (b) Nuclear energy
(c) Coal (d) Wood

219. Which is non-renewable source?
(a) Forests (b) Coal deposits
(c) Wild life (d) Wood

220. About what percentage of earth's surface is occupied by grass lands?
(a) 14% (b) 19%
(c) 10% (d) 36%

221. In Delhi and Kolkata, automobiles are responsible for:
(a) 50% of air pollution (b) 60% of air pollution
(c) 80% of air pollution (d) 90% of air pollution

222. Most commonest source of air pollution is :
(a) Transportation
(b) Industries
(c) Use of insecticide, pesticides
(d) Radioactive fall out

223. Importance of ecosystem lies in: (MPPMT 1993)
(a) Flow of energy (b) Cycling of materials
(c) Both (a) and (b) (d) None of these

224. When the vegetation of any region reaches climatic climax it is:
(a) Lithophytic (b) Xerophytic
(c) Mesophytic (d) Hydrophytic

225. Pneumatophores are helpful in:
(a) Protein synthesis (b) Respiration
(c) Transpiration (d) Carbohydrate metabolism

226. The primary source of energy in an ecosystem is:
(a) Sugar stored in plants
(b) Light from sun
(c) Heat liberated during fermentation of sugars
(d) Heat liberated during respiration

227. Food chains are met only in the: (MPPMT 1999)
(a) Sea (b) Forests
(c) Deserts (d) All of these

228. Which is logical sequence of carbon cycle?
(a) Photosynthesis–consumers–decomposer
(b) Decomposer–consumer–photosynthesis
(c) Photosynthesis–decomposer–consumer
(d) Consumer–photosynthesis–decomposer

229. Total production of oceans is:
(a) Equal to that of land (b) Half of the land
(c) Twice of land (d) 1/3rd of land

230. Gully erosion is by:
(a) Water (b) Wind
(c) Rivers (d) Grazing

231. Fertilizer obtained from sea bird along the west of Chile and Peru is: (BHU 1996)
(a) Guano (b) Bone meal
(c) Dung (d) Urea

232. Solar energy is trapped to maximum extent by:
(a) Wheat (b) Rice
(c) Sugar cane (d) Maize

233. Increasing accumulation of DDT in higher trophic levels of a food chain is:
(a) Biotic potential (b) Biological value
(c) BOD (d) Biological magnification

234. Thermocline is:
(a) Transitional zone between two vegetation types
(b) Vegetation of alpine region
(c) Region in a lake where there is maximum fall in temperature
(d) Region in lake where there is freezing temperature

235. Which is not usually an air pollutant? (MPPMT 1993)
(a) CO_2 (b) SO_2
(c) Hydrocarbons (d) NO_2

236. Lichens do not grow well in cities because:
(a) Absence of right type of algae and fungi
(b) Natural habitat is absent
(c) Lack of humidity
(d) Air pollution

237. Mulching helps in:
(a) Weed control
(b) Moisture conservation
(c) Soil fertility
(d) Improvement of soil structure

238. Which is the main factor of water pollution?
(a) Smoke (b) Industrial wastes
(c) Detergents (d) Ammonia

239. Non-ionizing radiations are:
(a) X-rays (b) UV-rays
(c) γ-rays (d) β-rays

240. Pollutant from motor car exhaust that causes mental disease is:
(a) Lead (b) Mercury
(c) NO_2 (d) SO_2

241. Cent-percent efficiency of energy entering an organism from outside is in:
(a) Unicellular green algae
(b) All green plants
(c) Some photosynthetic bacteria
(d) No plants

242. If precise quantitative measurements are made on a confined ecosystem in a laboratory, we find amounts of which of the following to be one way flow rather than cyclic?
(a) N_2 (b) C
(c) K (d) Free energy

243. Release of phosphates and nitrates in rivers and lakes lead to:
(a) Eutrophication
(b) Reduced algal growth
(c) Increased algal growth
(d) Increased growth of decomposers

244. Application of DDT produces pollution of:
(a) Air (b) Air and soil
(c) Water and soil (d) Air, water and soil

245. Biological treatment of sewage pollution is done with the help of:
(a) Lichens (b) Fungi
(c) Algae (d) None of these

246. If BOD value is below 4000 O_2/ litre waste, it is:
(a) Weak waste (b) Medium waste
(c) Strong waste (d) None of those

247. In submerged hydrophytes, gaseous exchange takes place through:
(a) Hydathodes (b) Stomata
(c) Lenticels (d) General surface

248. Diatoms are commonly:
(a) Benthos
(b) In upper surface of water bodies
(c) Saprophytic
(d) Parasitic

249. Fluoride toxicity in form of necrosis is in:
(a) Petiole (b) Midrib of lamina
(c) Leaf tip and margins (d) No where

250. Radioactive strontium in nuclear fall outs is :
(a) Sr^{80} (b) Sr^{90}
(c) Sr^{85} (d) Sr^{95}

251. Which does not cause any atmospheric pollution ?
(MPPMT 1993, 2000)
(a) Hydrogen (b) SO_2
(c) CO_2 (d) CO

252. Conifers are found in:
(a) Eastern ghats
(b) Western ghats
(c) Eastern and western Himalayas
(d) Rajasthan

253. Sunderbans are present in:
(a) Tamilnadu (b) Kerala
(c) West Bengal (d) Andaman Nicobar

254. Threat for human beings is:
(a) High population
(b) Less forest
(c) High population and pollution
(d) Deforestation

255. Abiotic component of ecosytem is :
(a) *Chlorella* (b) Water
(c) *Daphnia* (d) Bacteria

***256.** Which of the xerophytes face external and internal dryness?
(a) Ephemerals (b) Succulents
(c) Non-succulents (d) None of these

257. Which of the following is a 'true xerophyte'?
(a) *Asparagus* (b) *Argemone*
(c) *Zizyphus* (d) *Agave*

258. Phyllodes are found in :
(a) *Ruscus* (b) *Cocoloba*
(c) *Acacia* (d) None of these

***259.** Rolling of leaves in dry condition occurs in:
(a) *Calotropis* (b) *Aloe*
(c) *Psamma* (d) None of these

260. In which plant, roots upto maximum depth occurs?
(a) Cactus (b) *Acacia*
(c) *Ceiba* (d) *Prosopis*

261. Which are indices of atmospheric purity (IAP)?
[BCECE (P.T. Exam.) 2001]
(a) Ferns (b) Algae
(c) Fungi (d) Lichens

262. Which of the following are main cause of acid rains?
(a) CO_2 and CO (b) SO_2 and NO_2
(c) HF and hydrocarbons (d) None of these

263. Aeroallergens (a type of air pollutant) are:
(a) Flu gas (b) Spores and pollens
(c) Plume (d) Bacteria

264. Which is a secondary air pollutant?
(a) CO_2 (b) SO_2
(c) NO_2 (d) O_3

265. Which of the following causes phaeophytization phenomenon?
(a) Sewage (b) Aeroallergens
(c) SO_2 (d) NO_x

266. Highest CO concentration is in:
(a) Mumbai (b) Kolkata
(c) Kanpur (d) Delhi

267. Which plant is completely devoid of roots?
(a) *Azolla* (b) *Ceratophyllum*
(c) *Hydrilla* (d) *Vallisneria*

268. 'Compression wood' is formed due to:
(a) Water factor (b) Wind factor
(c) Light factor (d) None of these

269. Which is a bio-fertilizer?
(a) *Chlorella* (b) *Anabaena*
(c) *Cynodon* (d) None of these

270. Liberation of H_2S/foul smell in water of tanks, pond, etc., is due to: (MPPMT 1994)
(a) Anaerobiasis (b) Aerobiasis
(c) Psammophytes (d) Biological magnification

271. Which of the following components of ecosystem comes from outside?
(a) O_2 (b) Temperature
(c) Insects (d) Energy

272. Depleting source of energy is:
(a) Fossil fuels (b) Sunlight
(c) Wind (d) Water

273. Which of the following reduces global temperature?
(a) Green house effect (b) Albedo
(c) Both (a) and (b) (d) None of these

274. Which of the following is 'amphibious' in nature?
(a) *Vallisneria* (b) *Trapa*
(c) *Hydrilla* (d) *Ranunculus*

275. 'World earth day' is celebrated on:
(a) 22nd June (b) 22nd February
(c) 22nd April (d) 22nd March

276. Soil moisture can be expressed in terms of:
(a) pH (b) pF
(c) Pq (d) Q_{10}

277. Temperature of water at desired depths can be measured by:
(a) Thermometer (b) Thermistor
(c) Thermohygrograph (d) Thermograph

278. The molecular action of ultra-violet light is mainly reflected through:
(a) Photodynamic action
(b) Formation of pyrimidine
(c) Destruction of hydrogen bonds between DNA
(d) Formation of sticky metaphases

279. Grazing is an example of:
(a) Negative pollution (b) Positive pollution
(c) Sheet erosion (d) Gully erosion

280. Lead causes: (CPMT 1992)
(a) Soil pollution (b) Air pollution
(c) Radioactive pollution (d) All of these

281. Overgrazing by animals results in:
(a) Positive pollution (b) Negative pollution
(c) Sheet erosion (d) Rill erosion

282. Removal of the soil by action of wind and water is known as:
(a) Erosion (b) Fossilization
(c) Calcification (d) Sollination

283. When a man is the part of biotic community?
(a) Always
(b) Only when he lives in big cities
(c) Only when he lives in forests
(d) Never

284. The sequence:
Blue green algae → crustose lichens → foliose lichens → mosses → shrubs → dicotyledonous trees, represent:
(a) A phylogenetic trend
(b) A food pyramid
(c) Ecological succession trend
(d) Genetic drift

285. If the vegetation of a place is burnt the first one to appear will be:
(a) Mosses (b) Lichens
(c) Liver worts (d) Grasses

286. The succession initiated in pond of about 6 metres depth exhibits one of the following stages: (CPMT 1991)
(a) Floating plants → submerged plants→ reeds → herbs → shrubs → trees
(b) Submerged plants → floating plants → herbs → shrubs → trees
(c) Submerged plants →reeds →herbs →floating plants →shrubs→trees
(d) Shrubs →trees →submerged plants →floating plants →reeds →herbs

287. The basis of classification of hydrophyte, mesophyte and xerophyte is:
(a) Availability of water
(b) Tolerance to light
(c) Tolerance to temperature
(d) Tolerance to frost and rain

288. Heterophyllous plants are found in:
(a) Rooted and floating hydrophytes
(b) Submerged hydrophytes
(c) Free floating hydrophytes
(d) Halophytes

289. What type of leaves are present in *Ranunculus aquatilis*?
(a) Simple entire (b) Heterophyllous
(c) Homophyllous (d) Pinnately compound

290. *Typha* is an example of:
(a) Free floating hydrophyte
(b) Submerged hydrophyte
(c) Emergent hydrophyte
(d) Floating and attached hydrophyte

291. Absence of root, cuticle and stomata are the characteristic of:
(a) Hydrophyte (b) Mesophyte
(c) Xerophytes (d) Epiphytes

292. Water plants usually have:
(a) A reduced vascular system
(b) A well developed stomatal system
(c) A well developed root system
(d) A well developed vascular system

293. The stem of submerged water plants is soft and weak because:
(a) They are absolutely devoid of xylem
(b) The supporting tissue and xylem are feebly developed
(c) They totally lack phloem
(d) They do not have stomata

294. Useful adaptation for hydrophytes is: **(EAMCET 1991)**
(a) Large leaves
(b) Decrease in mechanical tissues
(c) Large mechanical tissue
(d) Increase in aerenchyma

295. Aerenchyma is present in which of the following plants?
(a) *Neptunia* (b) *Nelumbium*
(c) *Bryophyllum* (d) *Potamogeton*

296. Plants growing in xerophytic conditions have:
(a) Extensively developed root system, small and thick leaves
(b) Extensively developed shoot system
(c) Extensive air spaces
(d) Large flowers

297. Which of the following individual characters can confer relatively better adaptability for plants growing in deserts? **(EAMCET 1990)**
(a) Well developed root system
(b) Succulent leaves
(c) Reduction of leaf surface
(d) Thick cuticle

298. Extreme xerophytic conditions is shown by: **(CPMT 1991)**
(a) *Brassica* (b) *Capparis*
(c) Cactus (d) *Nerium*

299. Higher root shoot ratio is found in:
(a) Halophytes (b) Psammophytes
(c) Epiphytes (d) None of these

300. Mucilaginous tissues and chlorenchymatous cortex are found in:
(a) Halophytic xerophytes (b) Mesophytes
(c) Epiphytes (d) Insectivorous plants

301. Sunken stomata and multiple epidermis are found in the leaves of:
(a) Maize (b) *Nerium*
(c) *Nelumbium* (d) Neem

302. Which among the following plants does not fit into ecological group represented by the others?
(a) *Euphorbia* (b) *Vallisneria*
(c) *Acacia* (d) *Aloe vera*

303. Epiphytes are not found in Delhi because of:
(a) Moist air
(b) Semi arid climate
(c) Large number of automobiles
(d) Large number of factories

304. The classification of plants into hydrophytes, mesophytes and xerophytes was suggested by:
(a) Odum (b) Warming
(c) Weaver (d) Mishra

305. Vegetation of Sunderbans is:
(a) Monsoon type (b) Temperate evergreen
(c) Mangrove type (d) Desert type

306. Which of the following are plants of one group? **(Raj. PMT 1991)**
(a) *Mangifera* and *Rhizophora*
(b) *Rhizophora* and *Avicinia*
(c) *Rhizophora* and *Balanophora*
(d) *Balanophora* and *Avicinia*

307. An ecosystem may be defined as:
(a) Different communities of plants, animals and microbes together with their physiochemical environments
(b) Different communities of plants and microbes, plus their physio-chemical environment
(c) A localized association of several plants and animals
(d) None of the above

308. The term biocoenosis was coined by: **(MPPMT-2000)**
(a) Tansley (b) Carl Mobius
(c) Warming (d) R. Mishra

309. Correct definition of ecosystem is:
(a) A community of organisms interacting with one another
(b) The abiotic component of a habitat
(c) The part of the earth and its atmosphere which inhabits living organisms
(d) The community of organisms together with the environment in which they live

310. In an ecosystem in abiotic components which of the following occurs? **(CPMT 1990; MPPMT 1999)**
(a) Flow of energy
(b) Cycling of materials
(c) Consumers
(d) Flow of energy and cycling of materials

311. A food chain consists of:
(a) Producers only
(b) Consumers only
(c) Producers and consumers
(d) Decomposers only

312. In a food chain initial organisms are:
(a) Photosynthetes (primary producers)
(b) Primary consumers
(c) Secondary consumers
(d) Top consumers in the food chain

313. A crocodile had just eaten a lamb, when a hawk saw the crocodile, attacked it, and consumed it. The hawk is in ecological terms:
(a) A producer (b) A primary consumer
(c) A secondary consumer (d) A tertiary consumer

314. Equilibrium in atmosphere is maintained by:
(a) Producers
(b) Decomposers
(c) Producers and consumers
(d) Producers, consumers and decomposers

315. Which of the following is the correct sequence in food chain? **(CBSE 1991)**
(a) Fallen leaves → bacteria → insect larvae → birds
(b) Phytoplankton → zooplankton → fish
(c) Grasses → fox → rabbit
(d) Grasses → chameleon → insects → birds

316. The total energy fixed by a gram plant *(Cicer arietinum)* in an ecosystem on the whole is called: (CPMT 1991)
(a) Primary production (b) Gross production
(c) Secondary production (d) None of these

317. These belong to the category of primary consumers: (CET Karnataka 1993)
(a) Insects and cattles (b) Snakes and frogs
(c) Fishes (d) Eagles

*318. Animals which occupy the same trophic level are: (Re. Ex. CPMT 1991)
(a) Tiger and bees (b) Deer and bees
(c) Snake and earth (d) Crow and cow

319. In an ecosystem, decomposers include: (Re. Ex. CPMT 1991)
(a) Bacteria and fungi
(b) Only microscopic organisms
(c) Above two
(d) Above two plus macro-organisms

320. The transfer of energy from organism to organism in a natural community establishes:
(a) Food chains (b) Biological control
(c) Natural barriers (d) All of these

321. Driving force of ecosystem is: (Re. Ex. CPMT 1991; MPPMT 1999; CPMT 2001)
(a) Producer (b) Carbohydrate in plants
(c) Biomass (d) Solar energy

322. The pyramid that cannot be inverted in a stable ecosystem is pyramid of: (Re. Ex. CPMT 1991)
(a) Number (b) Energy
(c) Biomass (d) All of these

323. Flow of energy declines from lower to higher trophic level in ecosystem is mainly explained by: (Re. Ex. CPMT 1991)
(a) First law of thermodynamics
(b) Second law of thermodynamics
(c) Both (a) and (b)
(d) None of the above

324. Ecological factors are the factors which work:
(a) Singly
(b) In combination
(c) In complex combination interacting and modifying the effects of one another
(d) All of the above

325. Where do tropical forests occur in India?
(a) Jammu & Kashmir (b) Himachal Pradesh
(c) Bihar (d) Andamans

326. Conifers are found in:
(a) Rajasthan
(b) Eastern ghats
(c) Western ghats
(d) Eastern and western Himalayas

327. Vegetation of any place is primarily determined by:
(a) Amount of light (b) Rainfall
(c) Amount of soil-water (d) Soil type

328. Eutrophic lakes means:
(a) Lake poor in nutrients
(b) Lake rich in nutrients
(c) Lake poor in flora and fauna
(d) Lake lacking water

329. The hypersaline water are found in:
(a) Lake located in the alpine regions
(b) Lakes located in the arid and semi-arid regions
(c) Lakes located in the tropical regions
(d) Estuaries

330. The term 'Biosphere' is used for the zone of earth where life exists:
(a) On the lithosphere surface
(b) In the hydrosphere
(c) In the lithosphere and hydrosphere
(d) In the lithosphere, hydrosphere and atmosphere

331. The living organisms on or around earth constitute:
(a) Biome (b) Biosphere
(c) Community (d) Biocoenosis

332. Hydrological cycle is under the control of:
(a) Grasslands (b) Forests
(c) Planktons (d) Epiphytes

333. Which ecological cycle is directly driven by sunlight?
(a) Nitrogen (b) Phosphorus
(c) Hydrologic (d) Carbon

334. Maximum contribution of O_2 is from:
(a) Phytoplankton (b) Grassland
(c) Herbs and shrubs (d) Dense forests

335. Which of the following habitats is most unsuitable for primary productivity? (MPPMT 1999)
(a) Meadow (b) Forested river bank
(c) Cave (d) Pond

336. From the following which has maximum efficiency to convert solar energy into chemical energy?
(a) Tiger (b) Earthworm
(c) *Cuscuta* (d) *Chlorella*

337. Geothermal energy is:
(a) Non-renewable, conventional source of energy
(b) Non-renewable, non-conventional source of energy
(c) Renewable non-conventional source of energy
(d) Renewable, conventional source of energy

338. Renewable source of energy is: (CBSE 1991)
(a) Coal (b) Kerosene
(c) Petroleum (d) Biomass

339. The value of a resource depends upon :
(a) Quality of resource
(b) Quantity of resource
(c) Type of society and its needs
(d) All of the above

340. Water is considered to be:
(a) Renewable resource
(b) Non-renewable resource
(c) Degradable maintainable
(d) Non-degradable non-maintainable

341. All the following are proper plans for increasing agricultural production except:

(a) Expansion of irrigation facilities
(b) Increase in application of fertilizers
(c) Mechanisation of various aspects of farming
(d) Cutting of forests to add land for cultivation

342. Amount of water a soil can hold against the pull of gravity is known as:
(a) Hygroscopic water (b) Storage capacity
(c) Gravitational water (d) Field capacity

343. Water remaining in the soil after a plant has permanently wilted is:
(a) Hygroscopic water (b) Ground water
(c) Gravitational water (d) Capillary water

344. Property of soil based on the size of particles is termed: **(CBSE 1992)**
(a) Field capacity (b) Texture
(c) Water holding capacity (d) Colour

345. The least porous soil among the following is:
(a) Sandy soil (b) Clayey soil
(c) Loam soil (d) None of these

346. Deep black soil is considered to be highly productive due to high proportion of: **(CBSE 1991)**
(a) Silt and earthworm (b) Clay and humus
(c) Gravel and Ca^{2+} (d) Sand and Zn

347. Humus is an example of:
(a) Soil structure (b) Crystalloids
(c) Organic colloids (d) None of these

348. Deforestation will decrease: **(CBSE 1990)**
(a) Rainfall (b) Soil erosion
(c) Cyclones (d) Land slides

349. Air pollution is caused by:
(a) Automobile exhausts (b) Radioactive substance
(c) Smoke (d) All of these

350. In cities like Mumbai and Kolkata, the major air pollutants are:
(a) Carbon monoxide and oxides of sulphur
(b) Hydrocarbons and hot air
(c) Algal spores and marsh gas
(d) Ozone

351. Recent reports of acid rains in some industrial cities are due to the effect of atmospheric pollution by: **(CPMT 1991)**
(a) Excessive release of NO_2 and SO_2 by burning of fossil fuels
(b) Excessive release of CO_2 by burning of fuels like wood and charcoal, cutting of forests and increased animal population
(c) Excessive release of NH_3 by industrial plants and coal gas
(d) Excessive release of CO in atmosphere by incomplete combustion of coke, charcoal and other carbonaceous fuels in paucity of oxygen.

352. Which of the following atmospheric pollutants is not produced by the exhaust of motor vehicles in Delhi?
(a) SO_2 (b) Fly ash
(c) CO (d) Hydrocarbon gases

353. Acid rains contain: **(AFMC 2002)**
(a) SO_2, NO_2 (b) NO_3
(c) O_3 (d) CO

354. Generally speaking, the atmosphere in big cities is polluted most by: **(BHU 1990)**
(a) Radioactive fall out (b) Household waste
(c) Automobile exhausts (d) Pesticide residues

***355.** Ozone layer is disturbed by:
(a) Large number of automobiles
(b) Large number of factories
(c) Supersonic jets
(d) None of the above

356. The component of a living cell affected by the pollutant SO_2 is:
(a) Nucleus
(b) Chloroplast membrane system
(c) Cell wall
(d) Plasmodesmata

357. Minamata disease in Japan was caused by pollution of water by: **(Uttaranchal PMT 2001; BCECE 2002)**
(a) Lead (b) Cyanide
(c) Mercury (d) Methyl isocyanate

358. Release of phosphates and nitrates in water bodies (*i.e.*, rivers and lakes) leads to:
(a) Increased algal growth
(b) Increased growth of decomposers
(c) Nutrients enrichment
(d) Reduced algal growth

359. Domestic wastes contain : **(CPMT 1991)**
(a) Non-biodegradable pollutants
(b) Biodegradable pollutants
(c) Hydrocarbons
(d) None of the above

360. Herbicide DCMU kills weeds by:
(a) Inhibiting respiration (b) Inhibiting cell division
(c) Inhibiting CO_2 uptake (d) Inhibiting NO_3 uptake

361. Which of the following is the chief source of water and soil pollution?
(a) Agro industry (b) Mining
(c) Thermal power station (d) All of these

362. The pollution in a city like Delhi may be controlled to a great extent: **(CPMT 1991)**
(a) By proper sewage and proper exit of chemicals from factories
(b) By wide roads and factories away from the city
(c) By cleaning city and scanty use of pesticides
(d) All of the above

363. Soil conservation can be best achieved by having:
(a) Wind screens
(b) Good plant covers
(c) Restricted human activity
(d) Low rainfall

364. Complete breakdown of soil organic matter into minerals and humus is called:

(a) Humification (b) Mineralisation
(c) Pedogenesis (d) Laterisation

365. The study of interaction between living organisms and environment is called: (CBSE 1993)
(a) Ecosystem (b) Phytogeography
(c) Ecology (d) Phytosociology

366. Which is best for plant growth? (CBSE 1993)
(a) Loamy soil (b) Sandy soil
(c) Gravel (d) Clayey soil

367. The pyramid of numbers deals with the number of: (CBSE 1993)
(a) Species in a given area
(b) Sub species in a community
(c) Individuals in a community
(d) Individuals in a trophic level

368. Ultra-violet radiation from sunlight causes the reaction that produces: (CBSE 1993)
(a) CO (b) SO_2
(c) Ozone (d) Fluorides

369. Carnivores are: (MPPMT 1993)
(a) Usually primary consumers
(b) Usually secondary consumers
(c) Usually secondary or tertiary consumers
(d) Usually decomposers rather than consumers

370. If carbondioxide is withdrawn from the biosphere, which organism would first experience negative effects? (MPPMT 1993)
(a) Primary producers (b) Producers
(c) Secondary consumers (d) Tertiary consumers

371. Pollution can be controlled by: (MPPMT 1993)
(a) Sewage treatment
(b) Manufacturing electrically operated vehicles
(c) By checking atomic blasts
(d) All of the above

372. Ecosystem has two components: (MPPMT 1993)
(a) Plants and animals (b) Weeds and trees
(c) Biotic and abiotic (d) None of these

373. Ecosystem creates: (MPPMT 1993)
(a) Food chain (b) Food web
(c) Both (a) and (b) (d) None of these

374. Which causes water pollution? (MPPMT 1993)
(a) 2, 4–D and pesticides (b) Smoke
(c) Automobile exhaust (d) Aeroplanes

375. In lake ecosystem, pyramid of biomass is: (MPPMT 1993)
(a) Upright (b) Inverted
(c) Anything is possible (d) None of these

376. Man is: (CPMT 1993)
(a) Producer (b) Primary consumer
(c) Secondary consumer (d) Both (b) and (c)

377. Ozone layer is destroyed by: (CPMT 1993)
(a) More release of CO_2 (b) More release of O_2
(c) Uses of coal (d) Chlorofluorocarbons

378. Which of the following is a renewable resource? (CPMT 1993)
(a) Water (b) Forest
(c) Sunlight (d) Petrol

379. Air pollution is not caused by: (CPMT 1993)
(a) Pollen grains (b) Automobiles
(c) Industries (d) Hydro-electric power

380. Soil erosion can be prevented by: (CPMT 1993)
(a) Heavy rains (b) Deforestation
(c) Afforestation (d) Overgrazing

381. There is no vegetation in desert because of: (CPMT 1993)
(a) More activity of goats (b) Less rainfall
(c) People destroy them (d) All of these

382. Xeric condition refers to: (CBSE 1994)
(a) Low temperature (b) Low humidity
(c) High evaporation (d) Extreme temperature

383. The gas causing maximum destruction of ozone is: (CBSE 1994)
(a) CH_4 (b) Liquid NH_3
(c) SO_2 (d) CO

384. Which of the following is a major green-house gas? (CBSE 1994)
(a) CO_2 (b) Freon
(c) CFC (d) None of these

385. Second most important trophic level in lakes is: (CBSE 1994)
(a) Phytoplankton (b) Zooplankton
(c) Neuston (d) Benthos

386. Phytotrons are: (CPMT 2003)
(a) Green houses
(b) Houses in which plants are kept under controlled environment
(c) Houses in which plants are kept under controlled conc. of CO_2
(d) All of the above

387. Which of the following is a top carnivore?
(a) Snake (b) Vulture
(c) Dear (d) Frog

388. Man along with other living organisms live in:
(a) Stratosphere (b) Troposphere
(c) Mesophere (d) Thermosphere

389. Mor type of humus is:
(a) Neutral (b) Acidic
(c) Alkaline (d) None of these

390. Why the plants of alpine region have beautiful coloured flowers ? because:
(a) High intensity of light results in the formation of anthocyanin pigments
(b) High light intensity stops the formation of auxin
(c) Low intensity of light in alpine region favours the beautiful flower formation
(d) None of the above

391. Polymorphism or different shapes of leaf in the same individual is called:
(a) Isophylly (b) Heterophylly
(c) Phyllotaxy (d) Phyllody

392. Mangrove plant in Sunderban delta are adapted to:
(a) High water content (b) Saline condition
(c) Dry xeric condition (d) None of these

393. To check the soil erosion, best method is:
(a) Terrace farming (b) Shelter belts
(c) Wind breaks (d) Plant cover

394. In deserts of western U.P. and Rajasthan, soil erosion is chiefly caused by:
(a) Wind (b) Fast flowing rivers
(c) Land slides (d) Glaciers

395. Oxidation ponds involve:
(a) Chemical removal of pollutants
(b) Mechanical screening
(c) Biological reduction of organic matter
(d) None of the above

396. Excessive use of fertilizers often leads to the accumulation of nitrates in water when this water is utilized by animals, these nitrates:
(a) Are converted into non-toxic nitrites by intestinal bacteria
(b) Are converted into toxic nitrites by intestinal bacteria
(c) Get deposited in the intestine
(d) None of the above

*397. The water hyacinth has been used to reduce industrial pollution as it:
(a) Absorbs DDT
(b) Absorbs heavy metals
(c) Absorbs organic compounds
(d) All of the above

398. Release of hot water from thermal power plants is harmful as:
(a) It kills aquatic flora and fauna
(b) It holds more oxygen
(c) It holds less oxygen
(d) Both (a) and (c)

399. Shelter belts are:
(a) Plantation in short blocks
(b) Plantation in extensive belts
(c) Plantation covering the agricultural fields
(d) None of the above

400. Plantation of trees in short blocks to check soil erosion are called:
(a) Shelter belts (b) Wind breaks
(c) Wind screen (d) None of these

401. The harmful effect of monoculturing of *Eucalyptus* on soil is that:
(a) It reduces the water table
(b) It makes the soil acidic
(c) It makes the soil alkaline
(d) Both (a) and (b)

402. 'Ashok' and 'Neem' trees are planted in front of building because:
(a) They absorb harmful gases
(b) They absorb noise
(c) They emit scent
(d) All of the above

403. Pollen grains produced by *Xanthium* species cause allergy. They can be termed as:
(a) Radioactive pollutants (b) Biopollutants
(c) Chemical pollutants (d) Secondary pollutants

404. Peroxy acetyl nitrate (PAN):
(a) Increases the rate of photosynthesis
(b) Reduces the rate of photosynthesis
(c) Increases the rate of transpiration
(d) None of the above

405. Pollution caused by silica and iron dust leads to a disease called:
(a) Oedema (b) Pulmonary-oedema
(c) Cydosilcosis (d) None of these

406. *Primula* and *Saxifraga* are plants of:
(a) Tropical forests (b) Temperate forests
(c) Mangrove forests (d) Alpine vegetation

407. According to IUCN what percentage of flowering plants in world is endangered?
(a) 50% (b) 15%
(c) 10% (d) 5%

408. To guard against high wind velocity, the plants adopt:
(a) Tree habit (b) Climbing habit
(c) Rosette habit (d) Procumbent habit

*409. Indian grasslands are:
(a) Climax formations
(b) The products of primary succession
(c) Products of secondary succession of destructed forests
(d) None of the above

410. Aims of social forestry are:
(a) To meet the requirement of fuel, wood and fodder
(b) To create an ecological balance
(c) To utilize the waste land
(d) All of the above

411. Forests are :
(a) Inexhaustible natural resources
(b) Exhaustible but non-maintainable
(c) Exhaustible and maintainable
(d) None of the above

412. The percentage of moisture that is left in the soil at the time when the plant first wilts permanently:
(a) Saturation deficit (b) Wilting deficit
(c) Wilting co-efficient (d) Saturation co-efficient

413. The study of biotic and abiotic components of nature is known as:
(a) Ecology (b) Sociology
(c) Entomology (d) Anatomy

414. The natural process by which different groups or communities colonize the same area over a period in a definite sequence is called:
(a) Succession (b) Climax
(c) Ecosphere (d) Food-chain

415. Positive interaction includes:
(a) Commensalism (b) Cooperation
(c) Mutualism (d) All of these

416. Epiphytes can:
(a) Take water from air
(b) Manufacture their own food
(c) Seek shelter on the other plant
(d) All of the above

417. Ectotrophic mycorrhizae are very common on plants like:
(a) Pines, oaks, hickories and beech
(b) Pines, red maple and beech
(c) Maple and beech
(d) Pines and red maple

418. Endotrophic mycorrhizae occur in:
(a) Roots of red maple (b) Tissues of many orchids
(c) Members of Ericaceae (d) All of these

419. The zone of soil around the roots of higher plants is characterised by intense microbial activity known as:
(a) Phyllosphere (b) Rhizosphere
(c) Rhizoplane (d) Rhizophore

420. Specialised roots that penetrate the stem of the host establishing relationship with its conducting elements are called:
(a) Haustoria (b) Rhizoids
(c) Rhizoplane (d) Rhizophore

421. Which of the following is the example of predation?
(a) Browsing and grazing
(b) Seeds and seedling destruction
(c) Plants as food and carnivorous plants
(d) All of the above

422. Rate of storage of organic matter not used by heterotrophs is termed as:
(a) Gross primary product (b) Net primary productivity
(c) Closed system (d) Energy flow

423. The amount of water that can be absorbed from soil by plants is known as:
(a) Chresard (b) Available water
(c) Echard (d) Both (a) and (b)

424. Plants like *Hydrilla, Potamogeton* and *Vallisneria* belong to:
(a) Submerged floating hydrophytes
(b) Rooted submerged hydrophytes
(c) Rooted emergent hydrophyte
(d) None of the above

425. The process in which seeds germinate before they are shed from the parent plant is known as:
(a) Vivipary (b) Asexual propagation
(c) Polyploidy (d) Pneumatophores

426. In India mangroves are much prevalent on the sea shores of:
(a) Mumbai (b) Kerala
(c) Nicobar islands (d) All of these

427. Biological clocks are regulated by:
(a) External signals from the environment
(b) External signals coupled with physiological rythms and organism showing daily, seasonal changes
(c) Both (a) and (b)
(d) None of the above

428. Silent valley of Kerala is preserved because:
(a) It contains very rare species of plants and animals
(b) The soil is rich in minerals
(c) There the areas of land were used extensively for agricultural purpose
(d) It has pine trees

429. The quantity of inorganic materials like minerals present at any given time in ecosystem is called:
(a) Standing state (b) Standing crop
(c) Ecological efficiency (d) Food web

430. At each trophic level the energy value: (BHU 2002)
(a) Remains same (b) Decreases
(c) Increases (d) None of these

431. The total dry weight of organism per unit area in an ecosystem is called the:
(a) Standing crop (b) Standing state
(c) Biomass (d) Food web

432. The tendency of biological system to remain in a state of equilibrium is called:
(a) Biomass (b) Succession
(c) Post-climax (d) Homeostasis

433. The food-chain which starts from green plants and ends with carnivores passing in between through herbivores is called:
(a) Detritious food-chain (b) Grazing food-chain
(c) Food web (d) All of these

434. The species that occur in different geographical regions are called: (CBSE 1998)
(a) Sympatric (b) Allopatric
(c) Ecological equivalents (d) None of these

435. Biomagnification is the phenomenon of:
(a) Increase in the concentration of non-biodegradable substances, with the passage through food-chain, within the body of the organism
(b) Culturing of fungi from degradable substances
(c) Cultivation of dominant species
(d) Increased nitrogen fixation

436. Chief components of vegetation of arctic zone are:
(a) Lichen and mosses (b) Some algae
(c) *Betula* and *Salix* (d) All of these

437. Alluvial soils are chiefly found in:
(a) Indo-gangetic plain
(b) Deccan traps
(c) North-east region of peninsula
(d) North-west region

438. Tree saving and plantation movement was launched in 1950, it is known as:
(a) Forestry (b) Van Mahotsava
(c) Indian forests (d) Van forests

439. Forests can be conserved by :
(a) Protection of trees against fire
(b) Afforestation of land
(c) Controlled grazing and plantation of new fast-growing species
(d) All of the above

440. Deforestation results in:
(a) Increased soil erosion
(b) Flood and drought
(c) Desertification and extinction of plant species
(d) All of the above

441. UNEP stands for:
(a) United Nations Environmental Programme
(b) United Nations Ecological Programme
(c) United Nations Ecotype Programme
(d) United Nations Education Programme

442. The problem of desertification and deforestation is the result of:
(a) Overgrazing
(b) Indiscriminating felling of trees
(c) Over exploitation of land resources
(d) All of the above

443. The plants which have resulted in creation of greenbelt of hedges and wind breakers on the Tamilnadu coast are:
(a) *Gluicidia* (b) *Leucaena*
(c) *Podophyllum* (d) Both (a) and (b)

444. Chipko movement was started in:
(a) Tehri-Garhwal district of Uttaranchal
(b) Tehri-Garhwal district of M.P.
(c) Assam
(d) Kerala

445. The process in which top soil is lost is known as:
(a) Soil modification (b) Soil erosion
(c) Soil degradation (d) None of these

446. CPHERI deals with:
(a) Study of soil conservation
(b) Study of public health
(c) Study of plant hormones
(d) Study of plants

447. NEERI is:
(a) An organisation of environment
(b) An organisation of animals
(c) Man made ecosystem
(d) None of the above

448. When soil is removed like a thin covering from large area. The phenomenon is known as:
(a) Rill erosion (b) Gully erosion
(c) Sheet erosion (d) Wind erosion

449. Soil can be conserved by:
(a) Biological method (b) Mechanical method
(c) Stream bank protection (d) All of these

450. When the chemicals are lost from the 'A' horizon, the colour of the soil changes to light ash coloured. This process is known as:
(a) Melanization (b) Podosolisation
(c) Laterization (d) Glezation

451. On mountains vegetation is generally determined by:
(a) Temperature and rainfall
(b) Rainfall and humidity
(c) Transpiration and salinity
(d) Temperate and porosity of soil

452. Places with high temperatures alternating with low temperatures are known as :
(a) Mesotherms (b) Microtherms
(c) Megatherms (d) Hekistotherms

453. Which of the following is a erosion resistant plant?
(a) *Cynodon dactylon* (b) *Pteris*
(c) *Salvinia* (d) *Opuntia*

454. The plants which serve as useful wind breaks in Indian deserts are:
(a) *Lawsonia alba* and *Mangifera indica*
(b) *Agave americana* and *Acacia*
(c) *Cassia* and *Dalbergia sissoo*
(d) All of the above

455. Agricultural pollutants are:
(a) Pesticides (b) Herbicides
(c) Fungicides (d) All of these

456. It is said that Taj may be destroyed due to:
(a) Flood in Yamuna river
(b) Decomposition of marbles due to high temperature
(c) Air pollutants released from oil refinery of Mathura
(d) Photosynthesis

457. Substances which are toxic to plants are :
(a) PAN (b) O_3
(c) NO_3 (d) Both (a) and (b)

458. Which of the following types of erosion leaves no evidence?
(a) Rill erosion (b) Sheet erosion
(c) Gully erosion (d) None of these

***459.** The organization which protects the trade in endangered species at international level:
(a) IBWL (b) CITES
(c) WHO (d) WWF

460. The bacteria responsible for decreasing the soil fertility are known as:
(a) Deamination (b) *Rhizobium*
(c) Denitrifying bacteria (d) Nitrogen fixing

461. Sclerophyllous vegetation indicates:
(a) Heavy rainfall in winter and low during summer
(b) Heavy rainfall in summer and low during winter
(c) Heavy rainfall in winter as well as summer
(d) No rainfall in the year

Match the following (Q. 462–470)

462. I. Intraspecific interaction
II. Interspecific interaction
III. Habitat
IV. Biome
A. Interaction between the individual of same species
B. Interaction between different species
C. Natural surroundings
D. Community of animals and plants:
(a) I-A II-C III-B IV-D (b) I-D II-A III-B IV-C
(c) I-A II-B III-C IV-D (d) I-A II-D III-C IV-B

463. I. Sandy soil
II. Loamy soil
III. Loam soil
IV. Silt
A. 85% sand + 15% clay or silt
B. 70% sand + 30% clay or silt
C. 50% sand + 50% clay or silt both
D. 90% silt + 10% sand:
(a) I-A II-D III-C IV-B (b) I-A II-B III-D IV-C
(c) I-A II-D III-B IV-C (d) I-A II-B III-C IV-D

464. I. Helophytes
II. Psammophytes
III. Chasmophytes
IV. Oxylophytes
A. Saline soil
B. Sandy soil
C. Rock crevices
D. Acidic soil:
(a) I-A II-B III-C IV-D (b) I-A II-C III-B IV-D
(c) I-A II-D III-C IV-B (d) I-A II-C III-D IV-B

465. I. Hydrophyte
II. Xerophytes
III. Mesophytes
IV. Pneumatophores
A. Plant capable of growing in water deficient medium
B. Plants growing in places of moderate water supply
C. Plants growing in water or water rich substratum
D. Roots possessing breathing pores:
(a) I-C II-A III-B IV-D (b) I-A II-B III-D IV-C
(c) I-C II-B III-A IV-D (d) I-D II-A III-B IV-C

466. I. Phanerophytes
II. Chamaephytes
III. Cryptophytes
IV. Therophytes
A. Buds are situated close to the ground
B. Buds completely hidden in the soil
C. Buds naked or covered with scale
D. Seasonal plants completing their life cycle in a single favourable season:
(a) I-A II-B III-C IV-D (b) I-C II-A III-B IV-D
(c) I-C II-B III-A IV-D (d) I-A II-C III-B IV-D

467. I. Pioneers
II. Autogenic succession
III. Allogenic succession
IV. Ecesis
A. Vegetation which modifies its own environment and thus causing its own replacement
B. Replacement of existing community by external conditions
C. Establishment
D. Primary colonizers:
(a) I-D II-A III-B IV-C (b) I-A II-B III-C IV-D
(c) I-B II-A III-D IV-C (d) I-A II-D III-C IV-B

468. I. Gross primary productivity
II. Secondary productivity
III. Transducers
IV. Food web
A. Total assimilation
B. Remains mobile and does not remain in situ.
C. Green plants
D. Interlocking pattern:
(a) I-A II-B III-C IV-D (b) I-B II-C III-D IV-A
(c) I-C II-D III-A IV-B (d) I-A II-C III-B IV-D

469. I. Tropical wet-evergreen forests
II. Dry tropical deciduous forests
III. Montane sub-tropical forests
IV. Alpine zone
A. *Mangifera, Dipterocarpus*
B. *Betula utilis*
C. *Dendrocalamus, Bambusa, Lantana*
D. *Gnetum, Mangifera* and *Ficus*:
(a) I-A II-B III-C IV-D (b) I-A II-C III-D IV-B
(c) I-D II-B III-C IV-A (d) I-A II-C III-B IV-D

470. I. Circulation of water
II. Circulation of nitrogen
III. Circulation of food material
IV. Troposphere
A. Dust water and gases above the earth
B. Food-chain
C. Hydrological cycle
D. Nitrogen cycle:
(a) I-A II-B III-C IV-D (b) I-A II-D III-C IV-B
(c) I-C II-D III-B IV-A (d) I-C II-A III-D IV-B

471. The effect of pollution is first and most marked on:
(a) Natural flora of a place
(b) Natural balance of our environment
(c) Natural fauna of a place
(d) All of the above

472. Plume is:
(a) Visible smoke coming out of chimneys
(b) Gaseous mixture coming out of chimneys
(c) A kind of pollution injury on plants
(d) None of the above

473. Checking of re-radiating heat by atmospheric dust, water vapour, ozone, CO_2, etc., is known as: **(MPPMT 1992, 94)**
(a) Green house effect (b) Radioactive effect
(c) Ozone layer effect (d) Solar effect

474. The presence of O_3 in atmosphere of earth:
(a) Has been responsible for increasing the average global temperature in recent
(b) Is advantageous since it supplies O_2 for people travelling in jets
(c) Hinders higher rate of photosynthesis
(d) Helps in the checking the penetration of ultra-violet rays to earth

475. Ozone layer in stratosphere is affected by: **(CPMT 1993)**
(a) Excess CO_2 (b) Excess CO
(c) Chlorofluorocarbon (d) Low rainfall

476. Exposure of plants to high fluoride concentration results in necrosis or chlorosis characteristics in:

(a) Petiole but not in lamina
(b) Only midrib of lamina
(c) Leaf tip and leaf margin
(d) Stems tip only

477. Which major aerosol pollutant is present in jet aircraft emission? **(CBSE 1990)**
(a) SO_2 (b) Fluorocarbons
(c) CCl_4 (d) CO

478. Taj Mahal is threatened due to the presence of: **(CBSE 1995)**
(a) Chlorine (b) SO_2
(c) Oxygen (d) Hydrocarbons

479. When excess of sewage is dumped in the river, its BOD: **(CBSE 1995)**
(a) Increases (b) Slightly decreases
(c) Remains unchanged (d) Decreases drastically

480. The Mathura refinery smoke is thought to reduce the shine of Taj Mahal by:
(a) 3, 4-benzypyrene (b) Increasing UV radiations
(c) Acid rain (d) All of these

481. The insecticidal properties are shown by:
(a) *Ricinus communis* (b) *Cynodon dactylon*
(c) *Iberis amara* (d) All of these

482. Through food-chain radioactive Sr (Sr^{90}) is deposited in which part of human body?
(a) Kidneys (b) Thyroid
(c) Bones (d) Muscles

483. The 'Earth Summit' was held at:
(a) Geneva (b) New Delhi
(c) Sydney (d) Rio-de-Janeiro

484. The worst environmental hazards created accidents in nuclear power plant and MIC gas tragedy respectively in: **(CBSE 1996; BHU 2000)**
(a) Russia in 1990 and Bhopal in 1996
(b) Ukrain in 1986 and Bhopal in 1984
(c) Bhopal in 1994 and Russia in 1990
(d) Ukrain in 1988 and USA in 1984

485. The nature of climax community ultimately depends on: **(CBSE 1996)**
(a) Climate (b) Soil organism
(c) Bed rock (d) Pool of available nutrients

486. If the forest cover is reduced to half what is most likely to happen on a long term basis ?
(a) Tribals living in these areas will starve to death
(b) Cattle in these and adjoining areas will die due to lack of fodder
(c) Crop breeding programmes will suffer due to a reduced availability of variety of germplasm
(d) Large areas will become deserts

487. Rotation of crops is essential for: **(AFMC 1996)**
(a) Increasing quality of protein
(b) Increasing fertility of soil
(c) Getting different kinds of crops
(d) Increasing quality of minerals

488. A chemotherapeutic substance derived from living organisms that has inhibitory effect on disease producing bacteria is known: **(AFMC 1996)**
(a) Bactericide (b) Antibody
(c) Antibiotic (d) Exotoxin

489. The first link in any food-chain is always a green plant because: **(MPPMT 1996, 99)**
(a) They are widely distributed
(b) They are firmly fixed to the soil
(c) They alone have a capacity to fix atmospheric CO_2 in the presence of sunlight
(d) All of the above

490. Plants are known as purifier of air due to the process of:
(a) Respiration (b) Photosynthesis
(c) Transpiration (d) Desiccation

491. Food levels in an ecosystem are called:
(a) Trophic levels (b) Consumer levels
(c) Producer levels (d) Herbivore levels

492. A lake ecosystem is: **(MPPMT 1997)**
(a) Artificial (b) Abiotic
(c) Natural (d) Hydrological

*493. Air pollution effects are usually found on: **(MPPMT 1997)**
(a) Leaves (b) Flowers
(c) Stems (d) Roots

494. Water pollution: **(MPPMT 1997)**
(a) Increases oxygenation
(b) Decreases turbidity
(c) Increases turbidity and deoxygenation
(d) Increases photosynthesis

495. Oxides of sulphur and nitrogen are important pollutants of: **(MPPMT 1997)**
(a) Air and water (b) Air
(c) Water (d) Soil

496. A device where plants (herbs, shrubs and trees) are grown in a controlled environment is called as:
(a) Culture room (b) Autoclave
(c) Inoculation chamber (d) Phytotron

497. The manner in which values of BOD and COD change, as water pollution increases in a stream is:
(a) BOD decreases COD increases
(b) BOD increases COD decreases
(c) Both decreases
(d) Both increases

498. The disorder 'Blue baby syndrome' is caused due to pollution by:
(a) Nitrates (b) Chlorides
(c) Cyanides (d) None of these

499. Microbial conversion of ammonia to nitrate is termed as: **(MPPMT 1996)**
(a) Ammonification (b) Nitrification
(c) Denitrification (d) Nitrogen fixation

500. A red coloured soil deficient in organic matter is referred to as:

(a) Gleys (b) Laterite soil
(c) Podsols (d) Melanised soil

501. The sub-alpine ecosystem is a:
(a) Savannah ecosystem (b) Estuarine ecosystem
(c) Lotic ecosystem (d) Taiga ecosystem

502. Primary succession refers to the development of communities on a: (CBSE 1995)
(a) Pond, freshly filled with water after a dry phase
(b) Freshly cleared crop field
(c) Newly exposed habitat with no record of earlier vegetation
(d) Forest clearing after devastating fire

503. In upper atmosphere ultraviolet radiation from sunlight causes the reaction that produces:
(a) CO (b) SO_2
(c) Ozone (O_3) (d) Fluorides

504. Which one of the following pairs is a sedimentary type of biogeochemical cycle? (CBSE 1995)
(a) Oxygen and nitrogen
(b) Phosphorus and sulphur
(c) Phosphorus and carbondioxide
(d) Phosphorus and nitrogen

*505. The stratospheric ozone depletion leads to: (AIIMS 1992, 97)
(a) Global warming
(b) Increase in the incidence of skin cancer
(c) Forest fires
(d) Sound pollution

506. If we completely remove the decomposers from an ecosystem, the ecosystem functioning will be adversely affected because: (CBSE 1995; AMU 1995)
(a) Herbivores will not receive solar energy
(b) Rate of decomposition of other components will be very high
(c) Mineral movement will be blocked
(d) Energy flow will be blocked

*507. Which of the following isotopes is most dangerous to *Homo sapiens*? (CBSE 1995)
(a) Phosphorus—32 (b) Strontium—90
(c) Cesium—137 (d) Iodine—131

508. A community that starts the process of succession in a habitat is called: (Manipal 1997)
(a) Pioneer community (b) Abiotic community
(c) Biotic community (d) None of these

509. Which is the most stable ecosystem? (CBSE 1995)
(a) Desert (b) Ocean
(c) Mountain (d) Forest

510. In recent years there has been an increasing incidence of floods in the plains of northern India because: (Pb. PMT 1997)
(a) There has been an increase in annual rainfall
(b) The rate of silting of dams has gone up
(c) There has been increased deforestation in the catchment areas
(d) Increased areas of land is being self-cultivated

511. Increase in percentage of fauna and decrease in the flora may be dangerous because it enhances: (DPMT 1992, 96)
(a) Percentage of CO_2
(b) Percentage of O_2
(c) Percentage of diseases
(d) Percentage of radioactive pollution

512. The population of a place or an area tends to increase when: (AMU 1997)
(a) Predation increases (b) Emigration occurs
(c) Immigration occurs (d) Reproductivity decreases

513. "Catalytic converter" is used in automobiles: (AIIMS 1995)
(a) For removing the poisonous lead
(b) For converting CO and harmful hydrocarbons into CO_2 and water vapours
(c) For removing water
(d) None of the above

514. The concept of life form classes and biological spectrum was proposed by: (AMU 1997)
(a) C. Raunkiaer (b) F.E. Clements
(c) J.E. Weaver (d) G. Turesson

515. World environment day is: (BHU 1995; CPMT 2002)
(a) 5 June (b) 14 November
(c) 2 October (d) 28 February

516. Plants that lack perennating buds and are annuals are placed in the life form:
(a) Phanerophyte (b) Chamaecophyte
(c) Cryptophyte (d) Therophytes

517. In Tundra humus formed accumulate because: (BHU 1995)
(a) Low temperature inhibits bacterial activity
(b) Low temperature favours humus formation
(c) Conditions are dry
(d) There is no natural fire

518. During adverse season therophytes survive by: (CBSE 1997)
(a) Bulbs (b) Tubers
(c) Rhizomes (d) Seeds

519. From first or lower trophic level to upper trophic level energy is degraded from high grade form to low grade form, it can be made clear from: (AIIMS 1997)
(a) Second law of thermodynamics
(b) First law of thermodynamics
(c) Both (a) and (b)
(d) None of the above

520. Vegetation of Delhi is: (DPMT 1990, 94)
(a) Hydrophytic (b) Mesophytic
(c) Xerophytic (d) Hygrophytic

521. Individuals of the same species inhabiting in a particular locality constitute: (Pondicherry 1997)
(a) Population (b) Community
(c) Flora (d) Fauna

522. The maximum thinn of ozone layer over Antarctica occurs every year in t month of:
(a) January (b) September
(c) April (d) November

523. Desert can be converted into green land by planting:
(a) Oxylophytes (b) Psammophytes
(c) Halophytes (d) Tropical trees

524. Gene frequency of a population will continue to remain stable unless is not influenced by:
(a) Mutation (b) Selection
(c) Random mating (d) Random drift

525. The gaseous exchange in land plants occur through stomata. How do submerged hydrophytes exchange gases? **(AIIMS 1997)**
(a) Through lenticels
(b) Through stomata
(c) Through hydathodes
(d) Through general surface by diffusion

526. Dense evergreen vegetation of broad sclerophyllous leaves and shrubs with the fire resistant resinous plants is known as: **(AIIMS 1997)**
(a) Chaparral vegetation (b) Savannah vegetation
(c) Steppe grassland (d) Tundra vegetation

527. The biotic community together with its physical environment form an interacting working system is called: **(DPMT 1997; Pb. PMT 1997)**
(a) Ecosystem (b) Phytogeography
(c) Ecology (d) Phytosociology

528. Biomass of producers within specified area will be maximum in: **(Manipal 1997)**
(a) Forest ecosystem (b) Grassland ecosystem
(c) Pond ecosystem (d) Lake ecosystem

529. Plants growing on sandy soil are called: **(Manipal 1997)**
(a) Lithophytes (b) Psychrophytes
(c) Psammophytes (d) Oxylophytes

530. Noise pollution is measured in: **(DPMT 1997)**
(a) Decibel (dB) (b) Tonn
(c) Picogram (d) Kilogram

531. Which of the following are the nature's cleaner?
(a) Producers
(b) Consumers
(c) Symbionts
(d) Decomposers and scavengers

532. Which of the following ecosystem has highest rate of gross primary production? **(CBSE 1997)**
(a) Grasslands (b) Mangroves
(c) Coral reefs (d) Equatorial rain forest

533. 'Ozone day' is observed on: **(AIIMS 1996)**
(a) January, 30 (b) April, 21
(c) September, 16 (d) December, 25

534. 10% energy transfer law in food-chain was given by: **(AFMC 1997, 2002; BHU 2000; AIIMS 2000)**
(a) Lindemann (b) Tansley
(c) Elton (d) Raunkiaer

535. The tendency of an organism to maintain internal equilibrium in response to any change in its environment is called or (a tendency of biological systems to resist changes so as to remain in a state of equilibrium is called): **(CET Chandigarh 1997; AFMC 1997; Pb. PMT 1997)**
(a) Homeostasis (b) Epistasis
(c) Bioenergetics (d) Holocoenosis

536. The carbondioxide contents in atmospheric air is about: **(CBSE 1997)**
(a) 0.034% (b) 0.34%
(c) 3.34% (d) 6.5%

537. Most harmful types of environment pollutants are: **(CET Chandigarh 1997)**
(a) Human organic wastes
(b) Wastes from feed lots
(c) Non biodegradable chemicals
(d) Natural nutrients present in excess

538. In an ecosystem bacteria are considered as: **(MPPMT 1997)**
(a) Micro consumers (b) Macro consumers
(c) Primary consumers (d) Secondary consumers

539. Which one of the following statement is appropriate for "Red Data Book"? **(AMU 1997; Kerala PMT 2002)**
(a) It is a list of plants and animals present in the Red Sea
(b) It is the list of red pigmented
(c) It provides data on the effects of red light on photosynthesis
(d) It provides data on species threatened with extinction

540. The basic component of smog may be: **(AMU 1997)**
(a) O_3 (b) PAN
(c) O_3 and PAN (d) PPN and PBN

541. Acid rain is due to: **(AIIMS 1996; Pb. PMT 1997)**
(a) Sulphur dioxide pollution
(b) Carbon monoxide pollution
(c) Pesticide pollution
(d) Dust particles

542. In which ecosystem species diversity is low? **(Manipal 1997)**
(a) Deciduous forests (b) Deserts
(b) Grasslands (d) Tundras

543. Which city has most arsenic "As" pollution? **(AIIMS 1995)**
(a) Delhi (b) Kolkata
(c) Maharashtra (d) Ahmedabad

544. Soil erosion can be best prevented by: **(DPMT 1997)**
(a) Wind screens
(b) Good plant covers by more cultivation of plants
(c) Restricted human activity
(d) Checking the movements of grazing animals

545. The indiscriminate use of fertilizers and protein causes: **(AMU 1997)**
(a) Air pollution (b) Soil pollution
(c) Water pollution (d) All of these

546. The most common indicator organism that represent polluted water is: **(CBSE 1997)**

(a) *E. coli* (b) *P.typi*
(c) *C. vibrio* (d) *Entamoeba*

547. The wild life protection act was passed in: (AMU 1997)
(a) 1949 (b) 1972
(c) 1912 (d) 1991

548. Keystone species in ecosystem are those: (CBSE 1997)
(a) Present in maximum number
(b) That are most frequent
(c) Attaining a large biomass
(d) Contributing to ecosystem properties

549. Formation of 'Ozone hole' is maximum over: (CBSE 1997)
(a) India (b) Europe
(c) Antarctica (d) Africa

550. In coming years skin related disorders will be more common due to : (CBSE 1997)
(a) Pollutant in air (b) Use of detergents
(c) Water pollution (d) Depletion of ozone layer

551. *Acacia arabica* is a: (AFMC 1997)
(a) Halophyte (b) Mesophyte
(c) Xerophyte (d) Hydrophyte

552. Phosphate pollution is caused by: (CBSE 1997)
(a) Phosphate rocks only
(b) Agricultural fertilizer only
(c) Sewage and phosphate rocks
(d) Sewage and agricultural fertilizers

553. In increasing order of organizational complexity, which one of the following is the correct sequence? (DPMT 1997; CBSE 1997)
(a) Population, variety, community, ecosystem
(b) Population, species, community, ecosystem
(c) Population, community, species, ecosystem
(d) Species, variety, ecosystem, population

554. The succession as a result of changes in communities on earth's surface is called as: (AMU 1997)
(a) Biotic succession
(b) Climatic succession
(c) Physiographic succession
(d) Geographical succession

555. In any ecosystem or biological system there is transfer of energy at different trophic levels. The study of energy transfer at different trophic levels is known as: (CET Chandigarh 1997)
(a) Bioenergetics (b) Geobiocoenosis
(c) Holocoenosis (d) Biosystem

556. Where is tropical rain forest in India? (CPMT 1997)
(a) Assam (b) Himachal Pradesh
(c) Tamilnadu (d) Orissa

557. Most of the energy is present in: (CPMT 1997)
(a) Producers (b) Herbivores
(c) Ist trophic level (d) Carnivores

558. Contour farming is applied in: (CPMT 1997)
(a) Hill area (b) Sandy areas
(c) South India (d) All of these

559. Succulent perennials are best adapted for: (CPMT 1997)
(a) Desert (b) Hill areas
(c) Coastal areas (d) Saline soil

560. Vivipary occurs in: (CPMT 1997)
(a) Mangrove plants (b) *Acacia senegal*
(c) *Euphorbia* spp. (d) All of these

561. Non renewable source is: (CPMT 1997)
(a) Petroleum (b) Solar energy
(c) Water (d) Wind

562. Rooted submerged plant is: (CPMT 1998)
(a) *Wolffia* (b) *Vallisneria*
(c) *Nelumbium* (d) *Utricularia*

563. Conversion of ammonium salt to nitrite takes place by: (CPMT 1998)
(a) *Nitrosomonas* (b) *Nitrobacter*
(c) *Albugo* (d) *Penicillium*

564. 'Chipko movement' is associated with: (CPMT 1998; PMET Punjab 2003)
(a) Soil conservation (b) Forest conservation
(c) Pollution (d) Green revolution

565. Sunloving plants are: (CPMT 1998)
(a) Halophytes (b) Heliophytes
(c) Mesophytes (d) Xerophytes

566. Which important green-house gas other than methane is being produced from agricultural fields? (CBSE 1998)
(a) SO_2 (b) NH_3
(c) Arsine (d) Nitrous oxide

567. Which of the following communities is more vulnerable to invasion by outside animals and plants? (CBSE 1998)
(a) Tropical evergreen forest
(b) Temperate forests
(c) Oceanic islands communities
(d) Mangroves

568. How does carbon monoxide, a poisonous gas emitted by automobiles prevent transport of oxygen into body tissues? (CBSE 1998)
(a) By destroying the haemoglobin
(b) By obstructing the reaction of oxygen with haemoglobin
(c) By forming a stable compound with haemoglobin
(d) By changing oxygen into carbon dioxide

569. In desert grasslands which type of animals are relatively more abundant ? (CBSE 1998)
(a) Diurnal (b) Arboreal
(c) Aquatic (d) Fossorial

570. Two opposite forces operate in the growth and development of every population. One of them relates to the ability to reproduce at a given rate. The force opposing to it is called: (CBSE 1998)
(a) Environmental resistance
(b) Mortality
(c) Fecundity
(d) Biotic control

571. If there was no CO_2 in the earth's atmosphere, the temperature of earth's surface would be: (CBSE 1998)

(a) Dependent on the amount of oxygen in the atmosphere
(b) Higher than the present
(c) Lesser than the present
(d) The same

572. Which one of the following organisms is used as indicator of water quality? (CBSE 1998)
(a) *Beggiatoa* (b) *Chlorella*
(c) *Azospirillum* (d) *Escherischia*

573. A sewage treatment process in which a portion of the decomposer bacteria present in the waste is recycled in the beginning of the process, is called: (CBSE 1998)
(a) Cyclic treatment
(b) Primary treatment
(c) Activated sludge treatment
(d) Tertiary treatment

574. The main role of bacteria in the carbon cycle involves: (CBSE 1998)
(a) Assimilation of nitrogenous compounds
(b) Photosynthesis
(c) Chemosynthesis
(d) Digestion or breakdown of organic compounds

575. Plants such as *Prosopis*, *Acacia* and *Capparis* represent examples of tropical: (CBSE 1998)
(a) Grasslands (b) Thorn forests
(c) Deciduous forests (d) Evergreen forests

576. The zone of atmosphere that lies near the ground is: (AFMC 1998)
(a) Troposphere (b) Stratosphere
(c) Homosphere (d) All of these

577. In submerged plants, the stomata lie on: (AFMC 1998)
(a) Upper surface (b) Lower surface
(c) Not on any surface (d) Equally on both surface

578. The rate at which light energy is converted into the chemical energy of organic molecules is the ecosystem's: (CBSE 1998)
(a) Net secondary productivity
(b) Net primary productivity
(c) Gross primary productivity
(d) Gross secondary productivity

579. In a food-chain, the total amount of living material is depicted by: (AFMC 1998; BHU 2001)
(a) Pyramid of energy (b) Pyramid of numbers
(c) Pyramid of biomass (d) All of these

580. Pyramid of energy in a pond ecosystem is always: (AFMC 1998)
(a) Inverted (b) Upright only
(c) Irregular (d) Linear

581. Green house effect refers to: (CBSE 1999)
(a) Warming of the earth
(b) Desertification
(c) Cooling of earth
(d) Increased rainfall and greenery

582. Which habitat shows highest diversity of living species? (CBSE 1999)
(a) Desert (b) Temperate forest
(c) Tropical rain forest (d) Grassland

583. Bhopal gas tragedy (1984) was caused by leakage of: (CBSE 1999, 2000; CET J & K 2002; Kerala PMT 2002)
(a) SO_2 (b) NO_2
(c) CO (d) Methyl isocyanate

584. Interaction between biotic and abiotic components leads to formation of: (CBSE 1999)
(a) Species (b) Population
(c) Community (d) Society

585. How do nitrogen fixing bacteria contribute to N_2-cycle? (CBSE 1999)
(a) They change ammonium to nitrate
(b) Withdraw nitrate from soil
(c) Charge N_2 to ammonia
(d) Return N_2 to atmosphere

586. Pollution related occupation health hazard is: (CBSE 1999)
(a) Asthama (b) Pneumoconiosis
(c) Fluorosis (d) Silicosis

*587. How much of the chemical energy within producer tissue becomes chemical energy in herbivore tissue? (CBSE 1999)
(a) 10% (b) 30%
(c) 90% (d) 1%

*588. Pollution caused by persistent pesticides is relatively more hazardous to which type of organisms? (CBSE 1999)
(a) Herbivores (b) First level carnivores
(c) Producers (d) Top carnivores

589. Which of the following is true? (BHU 1999)
(a) *Nitrosomonas* convert NH_3 into NO_2^-
(b) *Nitrobacter* convert NO_2^- into NO_3^-
(c) Both (a) and (b)
(d) None of the above

590. Which of the following is a halophyte? (BHU 1999)
(a) *Hydrilla* (b) *Rhizophora*
(c) *Potamogeton* (d) All of these

591. Endangered species is: (AIIMS 1999)
(a) *Nepenthes khasiana* (b) *Mangifera indica*
(c) *Tectona grandis* (d) None of these

592. Group of individuals of same species in an area at a particular time is called: (AIIMS 1999)
(a) Population (b) Community
(c) Species (d) None of these

593. Freon produced by supersonics causes: (AIIMS 1999)
(a) Depletion of ozone layer
(b) Depletion of SO_2
(c) Depletion of CO_2
(d) None of the above

594. Ecosystem has two components: (MPPMT 1999; BHU 2000)
(a) Plants and animals (b) Weeds and trees
(c) Biotic and abiotic (d) Frogs and men

595. An ecosystem may be defined as: (MPPMT 1999)
(a) A localised association of several plants and animals
(b) Different communities of plants, animals and microbes together with their physico-chemical environments
(c) Different communities of plants and microbes plus their physico-chemical environments
(d) None of the above

596. Ecosystem may be defined as: (MPPMT 1999)
(a) Group of plants which act as energy suppliers
(b) Group of organisms which form population
(c) Functional unit for ecological studies
(d) None of the above

597. Green plants constitute: (MPPMT 1999)
(a) The first trophic level (b) The second trophic level
(c) The third trophic level (d) The fourth trophic level

598. The tip of ecological pyramid is occupied by: (MPPMT 1999)
(a) Herbivores (b) Carnivores
(c) Producers (d) None of these

599. The snakes are included under: (MPPMT 1999)
(a) Saprophytes (b) Primary consumers
(c) Second trophic level (d) None of these

600. The zooplanktons forms are: (MPPMT 1999)
(a) Primary consumers (b) Secondary consumers
(c) Carnivores (d) Primary producers

601. The transfer of energy from organisms to organisms in a natural community establishes: (MPPMT 1999)
(a) Food-chains (b) Biological control
(c) Natural barriers (d) All of these

602. Pneumatophores are present in the plants growing in: (CBSE 2000; BHU 2002)
(a) Marshy area (b) Marshy saline area
(c) Saline area (d) Sandy area

603. Which is amphibious plant? (CPMT 2000)
(a) *Casuarina* (b) *Polygonum*
(c) *Wolffia* (d) *Hydrilla*

604. If BOD of a river is high, it means: (CPMT 2000)
(a) It is not polluted
(b) It is very polluted
(c) It gets lower amount of light
(d) Its water temperature is lower

605. Aerosols reduce primary productivity by: (CPMT 2000)
(a) Competing with CO_2 (b) Reduce photosynthesis
(c) Being toxic (d) Destroy chlorophyll

606. Biotic components include: (CPMT 2000)
(a) Only consumers
(b) Consumers, producers and decomposers
(c) Producers and consumers only
(d) Producers only

607. Stem of submerged hydrophytes is absent because: (CPMT 2000)
(a) V. bundles are absent
(b) Xylem and phloem are absent
(c) Xylem and mechanical tissue are absent
(d) Stomata are absent

608. Herbivores represent: (CPMT 2000)
(a) I trophic level (b) II trophic level
(c) III trophic level (d) IV trophic level

609. Factors concerned with surface configuration are: (CPMT 2000)
(a) Topographic (b) Edaphic
(c) Climatic (d) None of these

610. Organism depending upon dead organic matter for food is: (CPMT 2000)
(a) Parasite (b) Saprophyte
(c) Autotroph (d) None of these

611. Which of the following causes 'green house effect'? (AFMC 2000)
(a) CO_2 and CFC compounds
(b) All gases which generally absorb infrared rays
(c) Oxygen
(d) None of the above

612. Which of the following is source of energy to an ecosystem? (MPPMT 2000)
(a) Solar energy
(b) Sugar stored
(c) Heat liberated during respiration
(d) ATP

613. If phytoplanktons are destroyed from sea, then: (MPPMT 2000)
(a) Algae will get more space to grow
(b) Primary consumers will grow luxuriantly
(c) Food-chain will be affected
(d) No effect will be seen

614. Which of the following biome is treeless? (MPPMT 2000)
(a) Savannah biome (b) Chapparal biome
(c) Temperate biome (d) Tundra biome

615. Food-chain consists of: (MPPMT 2000)
(a) Producer, consumer and decomposer
(b) Producer, carnivore and decomposer
(c) Producer and primary consumer
(d) Producer, herbivore and carnivore

616. Which is the most stable ecosystem? (MPPMT 2000; BHU 2002)
(a) Mountain (b) Desert
(c) Forest (d) Ocean

617. Water pollution is caused by: (MPPMT 2000)
(a) Ammonia (b) Phytoplankton
(c) Industrial effluent (d) Smoke

618. Lead (Pb) is mainly considered as: (MPPMT 2000)
(a) Soil pollutant (b) Water pollutant
(c) Air pollutant (d) Noise pollutant

619. The organisms which live in the bottom of lake, are called: (MPPMT 2000)
(a) Phytoplankton (b) Zooplankton
(c) Nekton (d) Benthos

620. Atmospheric humidity is measured by: (CET Karnataka 2000)
(a) Photometer (b) Potometer
(c) Auxanometer (d) Hygrometer

621. The concept of ecological pyramids was developed by: **(CET Karnataka 2000)**
(a) Darwin (b) Elton
(c) Reiter (d) Odum

622. The frog that feeds on an insect is a: **(CET Karnataka 2000)**
(a) Primary consumer (b) Secondary consumer
(c) Tertiary consumer (d) Decomposers

*623. As it travels along the food-chain the concentration of DDT: **(CET Karnataka 2000)**
(a) Increases (b) Decreases
(c) Stays constant (d) Fluctuates randomly

624. In a pond ecosystem, benthos means: **(BHU 2000)**
(a) Epineuston
(b) Periphyton
(c) Zooplankton on the water surface
(d) Primary consumers in the depth of a pond

625. Which is preserved in National park? **(BHU 2000)**
(a) Flora (b) Fauna
(c) Both (a) and (b) (d) None of these

626. Decomposers are: **(BHU 2001)**
(a) Autotrophs (b) Heterotrophs
(c) Autoheterotrophs (d) Organotrophs

627. The biotic part of ecosystem includes: **(BHU 2001; MPPMT 2001)**
(a) Producers (b) Consumers
(c) Decomposers (d) All of these

628. In a food-chain, lion is a: **(BHU 2001)**
(a) Primary consumer (b) Secondary producer
(c) Tertiary consumer (d) Secondary consumer

629. Increase in concentration of pollutants in higher trophic levels is called: **(BHU 2001)**
(a) Recycling (b) Eutrophication
(c) Biodegradation (d) Biomagnification

630. Water pollution is caused due to: **(BHU 2001)**
(a) Sewage and other wastes
(b) Industrial effluents
(c) Agricultural discharges
(d) All of the above

631. Wild-life is destroyed most when: **(AFMC 2001)**
(a) There is lack of proper care
(b) Mass scale hunting for foreign trade
(c) Natural habitat is destroyed
(d) Natural calamity

632. Ozone hole means: **(AFMC 2001)**
(a) Increase in concentration of ozone
(b) Decrease in concentration of ozone
(c) Same concentration of ozone
(d) Hole in stratosphere

633. Which is a degradable pollutant? **(MPPMT 2001)**
(a) DDT (b) Aluminium foil
(c) Domestic wastes (d) Mercury salts

*634. The earth and atmosphere in which organisms live, is called: **(MPPMT 2001; CPMT 2002)**
(a) Ecosystem (b) Biosphere
(c) Biocoenosis (d) Ecosom

635. A lake with nutrients is called: **(MPPMT 2001)**
(a) Trophic (b) Eutrophic
(c) Oligotrophic (d) Euphotic

636. Which of the following is an artificial ecosystem? **(MPPMT 2001)**
(a) Rice field (b) Forest
(c) Grassland (d) Lake

637. The flora and fauna in lakes or ponds are: **(AIIMS 2000)**
(a) Lentic biota (b) Lotic biota
(c) Abiotic biota (d) Field layer

*638. The abundance of a species in a population within its habitat, is called: **(AIIMS 2001)**
(a) Niche density (b) Absolute density
(c) Relative density (d) Regional density

639. The ecosystem consists of: **(AIIMS 2001)**
(a) Producers (b) Consumers
(c) Decomposers (d) All of these

640. Desert can be converted into green land by planting: **(AIIMS 2001)**
(a) Oxylophytes (b) Psammophytes
(c) Halophytes (d) Tropical trees

*641. July 11, is observed as: **(Manipal 2001)**
(a) Ozone day (b) Alzhemer's day
(c) World population day (d) Wild-life conservation day

642. Ozone hole is accelerated due to release of: **(Manipal 2001)**
(a) CO_2 (b) CFC's
(c) O_2 (d) SO_2

643. Which of the following is renewable resource? **(Manipal 2001)**
(a) Solar energy (b) Air
(c) Petroleum (d) Water

644. Biological oxygen demand is: **(Manipal 2001)**
(a) Amount of O_2 required by microbes to decompose organic waste
(b) Amount of O_2 produced by microbes on decomposing organic waste
(c) Amount of O_2 required by microbes to survive
(d) None of the above

645. The result of ozone hole is: **(CET Karnataka 2001)**
(a) Global warming
(b) Acid rain
(c) Green house effect
(d) The UV radiations reach the earth

646. What is the best pH of the soil for cultivation of plants? **(CBSE 2001)**
(a) 3.4–5.4 (b) 6.7–7.5
(c) 4.5–8.5 (d) 5.5–6

647. What is the intensity of sound in normal conversation? **(CBSE 2001)**
(a) 10–20 decibel (b) 30–60 decibel
(c) 70–90 decibel (d) 120–150 decibel

648. Reason of lung cancer is: (CBSE 2001)
(a) Coal mining (b) Calcium fluoride
(c) Cement factory (d) Bauxite mining

649. Which of the following is having both hydrophytic and xerophytic characters? (CPMT 2001)
(a) *Typha* (b) *Ranunculus*
(c) *Ceratophyllum* (d) *Nerium*

650. Correct sequence in ecosystem is: (CPMT 2001)
(a) Herbivores → Producers → Carnivores → Decomposers
(b) Producers → Herbivores → Decomposers → Carnivores
(c) Producers → Decomposers → Herbivores → Carnivores
(d) Producers → Herbivores → Carnivores → Decomposers

651. Presence of *E. coli* in water indicates: (CPMT 2001)
(a) Soil pollution (b) Sewage pollution
(c) Industrial pollution (d) All of these

652. 'Green house effect' is due to: (CPMT 2001)
(a) Depletion of O_3 layer and increase in CO_2 concentration
(b) Depletion of CO_2 layer and increase in O_3 concentration
(c) Depletion of O_3 layer and decrease in CO_2 concentration
(d) Afferestation and afforestation

653. Key-stone species are most easily recognized by:
(a) Removal experiments
(b) Addition experiments
(c) Multiplication experiments
(d) None of the above

654. The percentage of energy transferred from one trophic level to the next is called:
(a) NPP (b) GPP
(c) Ecological efficiency (d) Biogeochemical efficiency

655. Maximum biodiversity on land is shown by which biome?
(a) Tropical rain forests (b) Tundra biome
(c) Savannahs (d) Taiga biome

656. Permafrost is characteristic of:
(a) Taiga biome (b) Tundra biome
(c) Temperate grasslands (d) Temperate deciduous forests

657. Which biome is characterized by desert like levels of precipitation?
(a) Taiga
(b) Tundra
(c) Tropical forests
(d) Temperate deciduous forests

658. Biome characterized by multistoried vegetation is:
(a) Tundra (b) Taiga
(c) Tropical rain forests (d) Savannah

659. Lianas and epiphytes are common in:
(a) Tropical rain forests
(b) Tundra
(c) Temperate grasslands
(d) Taiga biome

660. Stratospheric ozone is measured in units:
(a) Decibel (b) Dobson
(c) ppm (d) Joule

661. Ozone in the atmosphere absorbs:
(a) All UV-C
(b) UV-A + UV-B
(c) All UV-C + most of UV-B
(d) UV-C + UV-A

662. Among green house gases, CO_2 contributes what percentage of global warming?
(a) 10% (b) 20%
(c) 50% (d) 80%

663. Which of the following plant species is in the category of endangered species?
(a) *Rauwolfia serpentina* (b) *Nepenthes khasiana*
(c) *Pinus gerardiana* (d) All of these

664. Which of the following represents 'hot spots' in India?
(a) Western ghats (b) North-East Himalayas
(c) Both (a) and (b) (d) None of these

665. Pink pages in red data book represent:
(a) Vulnerable species
(b) Rave species
(c) Endangered species
(d) Critically endangered species

666. SO_2 affects: [BCECE (P.T. Exam.) 2001]
(a) Nuclear membrane (b) Cell wall
(c) Mitochondria (a) All membrane system

667. Velamen tissue is found in: [BCECE (P.T. Exam.) 2001]
(a) Mesophytes (b) Epiphytes
(c) Hydrophytes (d) Xerophytes

668. Phytoplanktons are an important biotic component of: [BCECE (P.T. Exam.) 2001]
(a) Grassland ecosystem (b) Pond ecosystem
(c) Forest ecosystem (d) None of these

669. Soil transported by air is called: (CPMT 2002)
(a) Eolian (b) Alluvial
(c) Aerial (d) Residual

670. The sequence of succession is: (CPMT 2002)
(a) Lichens → Mosses → Grass → Shrubs → Trees
(b) Trees →Shrubs → Lichens → Mosses → Grass
(c) Mosses → Shrubs → Trees → Lichens → Grass
(d) Lichens → Trees → Mosses → Grass → Shrubs

671. The stem of submerged water plants is soft and weak because: (JIPMER 2002)
(a) They are absolutely devoid of xylem
(b) They totally lack phloem
(c) They do not have stomata
(d) The supporting tissue and xylem are feebly developed

672. Which of the following gases contributes to global warming? (CET Karnataka 2002)
(a) Nitrogen dioxide (b) Carbon dioxide
(c) Sulphur dioxide (d) Carbon monoxide

673. Acid rain will not affect: (BCECE 2002)
(a) Plants (b) Lithosphere
(c) Animals (d) Ozone layer

674. Soil carried by gravity is: (BCECE 2002)
(a) Alluvial (b) Colluvial
(c) Elluvial (d) Glacial

675. The pyramid of number in a grassland ecosystem is: (BHU 2002)
(a) Linear (b) Inverted
(c) Upright (d) Negative

676. The abundance of a species population within its habitat is called: (AIIMS 2002)
(a) Niche density (b) Regional density
(c) Relative density (d) Absolute density

677. Green muffler is used against which type of pollution? (AIIMS 2002)
(a) Air (b) Water
(c) Soil (d) Noise

678. Species is a: (AFMC 2002)
(a) Group immediately below a phylum
(b) Closely related interbreeding population
(c) Taxonomic division of similar genera
(d) Closely related non-breeding population

679. Which of the following does not have stomata? (AFMC 2002)
(a) Hydrophytes (b) Mesophytes
(c) Xerophytes (d) Submerged hydrophytes

680. Maximum green house gas is released by which country? (CBSE 2002)
(a) India (b) France
(c) USA (d) Britain

681. Which of the following is a correct pair? (CBSE 2002)
(a) *Cuscuta*-parasite (b) *Dischidia*-insectivorous
(c) *Opuntia*-predator (d) *Capsella*-hydrophyte

682. Bamboo plant is growing in a far forest, then what will be the trophic level of it? (CBSE 2002)
(a) First trophic level (T_1) (b) Second trophic level (T_2)
(c) Third trophic level (T_3) (d) Fourth trophic level (T_4)

683. Two different species can not live for long duration in the same niche or habitat. This law is: (CBSE 2002)
(a) Allen's law
(b) Gause's law
(c) Competitive exclusion principle
(d) Weisman's theory

684. Chipko movement for saving trees was started in: (AFMC 2002)
(a) Karnataka (b) Tehri-Garhwal
(c) Punjab (d) Haryana

685. Which of the following weeds must be removed earliest from the field? (AFMC 2002)
(a) *Eichhornia* (b) *Parthenium*
(c) *Salvinia* (d) *Nostoc*

686. A bacteria live in the body of the host, in which bacteria is benefitted and host is not affected. The bacteria is: (AFMC 2002)
(a) Symbiont (b) Commensal
(c) Parasite (d) Predator

***687.** An example of physiological xerophyte is: (EAMCET 2002)
(a) *Salvinia* (b) *Euphorbia*
(c) *Salicornia* (d) *Agave*

688. SO_2 pollution is indicated by: (MPPMT 2002)
(a) Grasses (b) Mosses
(c) Lichens (d) Fossils

689. B.O.D. is connected with: (MPPMT 2002)
(a) Organic matter (b) Microbes
(c) Both (a) and (b) (d) None of these

690. Acid rain is due to increase in atmospheric concentration of: (MPPMT 2002)
(a) Ozone and dust (b) CO_2 and CO
(c) SO_3 and CO (d) SO_2 and NO_2

691. Group of organisms of same species in a given area at a time is: (Kerala PMT 2002)
(a) Community (b) Population
(c) Genera (d) Biosphere
(e) Ecosystem

692. Which of the following is a 2° (secondary) pollutant? (Kerala PMT 2002)
(a) PAN (b) SO_3
(c) SO_2 (d) H_2S
(e) NO_2

693. Pea root-*Rhizobium* bacterium shows: (Kerala PMT 2002)
(a) Symbiosis (b) Commensalism
(c) Predation (d) Parasitism
(e) Scavenging

694. Group of two or more than two plant species is called as: (Raj. PMT 2002)
(a) Plant community (b) Animal ecosystem
(c) Plant ecosystem (d) Ecological niche

695. Fungi in a forest ecosystem is: (CPMT 2003)
(a) Producer (b) Decomposer
(c) Top consumer (d) Autotroph

696. Energy enters in a food chain through: (CPMT 2003)
(a) Producers (b) Primary consumers
(c) Secondary consumers (d) Tertiary consumers

697. Ozone hole results in: (CPMT 2003)
(a) UV-radiation reaches the earth
(b) Cataract
(c) Increase in skin cancer
(d) All of the above

698. Soil erosion is prevented by: (CPMT 2003)
(a) Deforestation
(b) Afforestation
(c) Reduction of CFCs production
(d) Use of CNG in all transports

699. The conversion of NO_3 to N_2 is called: (CPMT 2003)
(a) Nitrification (b) Denitrification
(c) Ammonification (d) Nitrogen fixation

700. The purpose of crop rotation is: (CPMT 2003)
(a) To increase the fertility of soil
(b) To decrease the fertility of soil

(c) To prevent soil erosion
(d) To prevent water erosion

701. Which of the following is a nitrogen fixing organism? (CPMT 2003)
(a) BGA (b) *Rhizobium*
(c) Both (a) and (b) (d) *Aspergillus*

702. 'Chernobyl' nuclear tragedy occured on which date ? (BHU 2003)
(a) 3rd December 1984 (b) April 1986
(c) 6th August 1945 (d) 9th August 1945

703. The species very near to extinction if conservational measures are not prompt are called as: (BHU 2003)
(a) Threatened species (b) Rare species
(c) Endangered (d) Vulnerable

704. A threatened species category includes only: (Orissa JEE 2003)
(a) Only endangered species
(b) Only vulnerable species
(c) Endangered and rare species
(d) Endangered, vulnerable and rare species

705. CFCs are not recommended to be used in refrigerator because they: (DPMT 2003; MGIMS 2003)
(a) Increase temperature (b) Deplete ozone
(c) Affect environment (d) Affect human body

706. Maximum productivity is found in: (DPMT 2003)
(a) Grassland (b) Tropical rain forest
(c) Ocean (d) None of these

707. Which of the following does not occur when sewage is discharged into water? (DPMT 2003)
(a) Increase in O_2
(b) Cyanophycean blooms occur
(c) Depletion of O_2 layers
(d) Eutrophication

708. Number of plant species reported in India are: (DPMT 2003)
(a) 45,000 (b) 40,000
(c) 90,000 (d) 50,000

709. The taxa which is believed likely to join the endangered category in near future is called: (Kerala PMT 2003)
(a) Extinct (b) Rare
(c) Vulnerable (d) Out of danger
(e) Living fossil

710. The soil pollutants that affect the food chain and food web by killing micro-organisms and plants are: (Kerala PMT 2003)
(a) Nitrogen oxides (b) Pathogen
(c) Chemical fertilizers (d) Agricultural waste
(e) Pesticides

711. Eutrophication results in reduction of: (Kerala PMT 2003)
(a) Mineral salts (b) Dissolved oxygen
(c) Protozoa (d) Dissolved nitrate
(e) Dissolved hydrogen

712. Why the tropical deciduous forest trees shed their leaves? (Kerala PMT 2003)
(a) To save energy
(b) To protect itself from heat
(c) To enhance rate of respiration
(d) To prevent loss of water
(e) To reduce the rate of respiration

713. The different forms of interbreeding species that live in different geographical regions are called: (Kerala PMT 2003)
(a) Sibling species (b) Sympatric species
(c) Allopatric species (d) Polytypic species
(e) Monotypic species

714. The rate of conservation of light energy into chemical energy of organic molecule in an ecosystem is: (Kerala PMT 2003)
(a) Net primary productivity
(b) Gross primary productivity
(c) Net secondary productivity
(d) Gross secondary productivity
(e) None of the above

715. Ozone saves the biosphere by absorbing the high energy radiation called: (Kerala PMT 2003)
(a) Infra-red (b) Ultraviolet rays
(c) X-rays (d) Gamma rays
(e) Cosmic rays

716. The possible beneficial affect of grazing animals is the: (BV Pune 2003)
(a) Removal of wild animals
(b) Eradication of weeds
(c) Removal of wild plants
(d) Addition of their excrete to the soil

717. U^{238} emits: (BV Pune 2003)
(a) α-rays (b) β-rays
(c) γ-rays (d) None of these

718. Photochemical transformation of the automobile exhaust emission in UV wavelength of sunlight results into: (BV Pune 2003)
(a) CH_4 and C_6H_6 (b) O_3 and PAN
(c) CO_2 and NO_2 (d) CO and CO_2

719. *Escherichia coli* is used as an indicator organism to determine pollution of water with: (CBSE 2003)
(a) Faecal matter (b) Heavy metals
(c) Industrial effluents (d) Pollen of aquatic plants

720. A thin film of water held by the soil particles under the influence of internal attractive force is called which of the following water? (PMET Punjab 2003)
(a) Capillary (b) Combined
(c) Hygroscopic (d) Gravitational

721. The interaction in nature, where one gets benefit on expense of other, is: (PMET Punjab 2003)
(a) Predation (b) Parasitism
(c) Scavenging (d) Commensalism

722. Which of the following is most productive ecosystem? (PMET Punjab 2003)
(a) Rice (b) Wheat
(c) Maize (d) Sugarcane

ANSWERS

1—c	2—b	3—b	4—c	5—c	6—c	7—c	8—b	9—a	10—c	11—a	12—b
13—c	14—c	15—b	16—d	17—c	18—b	19—b	20—b	21—d	22—a	23—a	24—b
25—a	26—b	27—b	28—a	29—b	30—c	31—a	32—b	33—b	34—a	35—a	36—c
37—d	38—c	39—d	40—c	41—c	42—c	43—a	44—c	45—c	46—c	47—b	48—c
49—b	50—a	51—a	52—b	53—b	54—a	55—b	56—a	57—b	58—c	59—b	60—c
61—c	62—d	63—a	64—c	65—b	66—b	67—a	68—a	69—b	70—b	71—b	72—b
73—c	74—b	75—b	76—c	77—d	78—b	79—c	80—c	81—d	82—a	83—c	84—c
85—b	86—c	87—b	88—a	89—c	90—b	91—c	92—b	93—b	94—b	95—a	96—a
97—b	98—c	99—b	100—b	101—a	102—a	103—b	104—a	105—a	106—b	107—d	108—b
109—b	110—b	111—c	112—c	113—b	114—b	115—c	116—c	117—d	118—a	119—a	120—b
121—b	122—a	123—b	124—c	125—c	126—d	127—c	128—c	129—d	130—c	131—b	132—d
133—d	134—c	135—d	136—c	137—c	138—c	139—d	140—b	141—d	142—c	143—a	144—c
145—a	146—b	147—d	148—d	149—a	150—d	151—b	152—b	153—a	154—d	155—b	156—a
157—c	158—b	159—b	160—c	161—c	162—a	163—c	164—c	165—d	166—b	167—c	168—c
169—c	170—d	171—c	172—b	173—b	174—c	175—b	176—a	177—c	178—d	179—b	180—b
181—a	182—b	183—a	184—d	185—d	186—a	187—b	188—b	189—a	190—a	191—b	192—b
193—c	194—a	195—b	196—a	197—b	198—b	199—c	200—b	201—b	202—c	203—b	204—d
205—b	206—a	207—b	208—c	209—b	210—c	211—a	212—c	213—a	214—d	215—b	216—a
217—c	218—a	219—b	220—b	221—c	222—a	223—c	224—c	225—b	226—b	227—d	228—a
229—b	230—a	231—a	232—c	233—d	234—c	235—a	236—d	237—b	238—b	239—b	240—a
241—d	242—d	243—a	244—d	245—c	246—b	247—d	248—b	249—c	250—b	251—a	252—c
253—c	254—c	255—b	256—c	257—c	258—c	259—c	260—d	261—d	262—b	263—b	264—d
265—c	266—b	267—b	268—b	269—b	270—a	271—d	272—a	273—b	274—d	275—c	276—b
277—b	278—c	279—a	280—a	281—b	282—a	283—a	284—c	285—b	286—b	287—a	288—a
289—b	290—c	291—a	292—a	293—b	294—d	295—d	296—a	297—d	298—c	299—b	300—a
301—b	302—b	303—b	304—b	305—c	306—b	307—a	308—b	309—d	310—d	311—c	312—a
313—d	314—d	315—b	316—a	317—a	318—b	319—a	320—b	321—d	322—b	323—b	324—c
325—d	326—d	327—b	328—b	329—b	330—d	331—b	332—b	333—c	334—a	335—c	336—d
337—b	338—d	339—c	340—c	341—d	342—d	343—a	344—b	345—b	346—b	347—c	348—a
349—d	350—a	351—a	352—b	353—a	354—c	355—c	356—b	357—c	358—c	359—b	360—c
361—d	362—d	363—b	364—b	365—c	366—a	367—d	368—c	369—c	370—b	371—d	372—c
373—b	374—a	375—b	376—d	377—d	378—b	379—d	380—b	381—b	382—b	383—a	384—a
385—b	386—b	387—b	388—b	389—b	390—a	391—b	392—b	393—d	394—a	395—c	396—b
397—b	398—d	399—b	400—b	401—d	402—b	403—b	404—b	405—c	406—d	407—c	408—c
409—c	410—d	411—c	412—c	413—a	414—a	415—d	416—d	417—a	418—d	419—b	420—a
421—d	422—b	423—d	424—b	425—a	426—d	427—b	428—a	429—a	430—b	431—c	432—d
433—b	434—b	435—a	436—d	437—a	438—b	439—d	440—d	441—a	442—d	443—b	444—a
445—b	446—b	447—a	448—c	449—d	450—b	451—a	452—a	453—a	454—d	455—d	456—c
457—d	458—a	459—b	460—c	461—a	462—c	463—d	464—a	465—a	466—b	467—a	468—a
469—b	470—c	471—a	472—a	473—a	474—d	475—c	476—c	477—b	478—b	479—a	480—c
481—a	482—c	483—d	484—b	485—d	486—d	487—b	488—c	489—c	490—b	491—a	492—c
493—a	494—c	495—b	496—d	497—d	498—a	499—b	500—b	501—d	502—c	503—c	504—b
505—b	506—c	507—b	508—a	509—b	510—c	511—a	512—b	513—b	514—a	515—a	516—d
517—a	518—d	519—a	520—c	521—a	522—b	523—b	524—d	525—d	526—a	527—a	528—a
529—c	530—a	531—d	532—d	533—c	534—a	535—a	536—a	537—c	538—a	539—d	540—c

Contd.

541—a	542—d	543—d	544—b	545—c	546—a	547—b	548—d	549—c	550—d	551—c	552—d
553—b	554—a	555—a	556—d	557—c	558—a	559—a	560—a	561—b	562—b	563—a	564—b
565—b	566—b	567—d	568—c	569—d	570—b	571—c	572—d	573—c	574—d	575—b	576—a
577—c	578—c	579—c	580—b	581—a	582—c	583—d	584—c	585—c	586—b	587—a	588—d
589—c	590—b	591—a	592—a	593—a	594—c	595—b	596—c	597—a	598—b	599—c	600—a
601—a	602—b	603—b	604—b	605—c	606—b	607—c	608—b	609—a	610—b	611—b	612—a
613—c	614—d	615—a	616—d	617—c	618—c	619—d	620—d	621—b	622—b	623—a	624—d
625—c	626—b	627—d	628—c	629—d	630—d	631—c	632—b	633—c	634—b	635—b	636—a
637—a	638—a	639—d	640—b	641—c	642—b	643—d	644—a	645—d	646—d	647—b	648—c
649—a	650—d	651—b	652—a	653—a	654—c	655—a	656—b	657—b	658—c	659—a	660—b
661—c	662—c	663—d	664—c	665—d	666—d	667—b	668—b	669—a	670—a	671—d	672—b
673—d	674—b	675—c	676—a	677—d	678—b	679—d	680—c	681—a	682—a	683—c	684—b
685—b	686—b	687—c	688—c	689—c	690—d	691—b	692—a	693—a	694—a	695—b	696—a
697—d	698—b	699—b	700—a	701—c	702—b	703—c	704—d	705—b	706—b	707—a	708—a
709—c	710—c	711—c	712—d	713—c	714—b	715—b	716—d	717—a	718—b	719—a	720—c
721—a	722—d										

EXPLANATION OF SELECTED QUESTIONS (*)

19. Therophytes are annuals or seasonal plants which complete their life cycle in a single season and survive in adverse conditions in the form of seeds.
20. Concentration of CO_2 in atmosphere is 0.03% or 300 ppm (parts per million).
62. Epiphytes have aerial roots containing velamen tissue, which is hygroscopic in nature and hence absorb water from moist atmosphere.
78. Epiphytes are common in places rich in moisture or where rainfall is throughout the year (tropical rain forests).
121. Conductivity meter is an apparatus which measure total soluble salts in soil.
124. Red soils of Orissa are so because of presence of high concentration of iron (Fe).
126. As 300 ppm is normal concentration of CO_2, hence there is no effect on plants.
152. Silent valley containing very rare species of plants and animals is in Kerala.
256. Non-succulents are the true xerophytes which face both external and internal dryness.
259. Leaves of *Psamma*, *Agropyron* and *Poa* contain motor cells or bulliform cells in their upper epidermis, which help in rolling of leaves during dry conditions.
318. Both deer and bee are primary consumers or consumers of first order.
355. Supersonic jets release aerosols containing CFC, which disturbs stratospheric ozone layer.
397. *Eichhornia* (water hyacinth) has property of reducing pollution by absorbing heavy metals.
409. Indian grasslands are the result of destruction and modification of tropical deciduous forests by cutting, grazing and fire, *i.e.*, are products of secondary succession of destructed forests.
459. CITES (Convention on International Trade in Endangered Species) is an organization which protects the trade in endangered species at international level.
493. Air pollution effects or injury symptoms due to air pollution are mostly observed on leaves.
505. Ozone depletion results in incidence of skin cancer and cataract.
507. Sr^{90} in radioactive isotope which gets accumulated in bone marrow and results in blood cancer or leukemia.
587. According to Lindemann's 10% law of energy transfer, only 10% of chemical energy within producer tissue becomes chemical energy in herbivore tissue.
588. Persistent or non-degradable pesticides are biologically magnified and their maximum concentration occurs in top carnivores and hence are more hazardous to them.
623. DDT is non-degradable and hence biologically magnified, *i.e.*, concentration goes on increasing with each and every trophic level along the food-chain.
634. The whole earth is a huge ecosystem called biosphere or ecosphere.
638. Abundance of a species in a population, within its habitat is called niche density. Niche is the functional role of organisms in an ecosystem.
641. July 11, is observed as 'World population day'.
687. *Salicornia* is a halophyte and thus faces physiological dryness.

TEST PAPER–UNIT–8

1. Who coined the term Ecology?
(a) Reiter, H. [✓ (b) Haeckel, E.]
(c) Dudgeon (d) Odum

2. Who is known as 'Father of Indian Ecology'?
(a) R. Mishra (b) Stephen Hales
(c) Priestley (d) Ingenhouz

3. Mor humus is the characteristic of:
(a) Latosols (b) Podsols
(c) Gleys (d) All of these

4. PAN (Peroxy acetyl nitrate) causes:
(a) Increase the rate of photosynthesis
(b) Death of the plant by checking respiration
(c) Death of the plant by checking light reaction
(d) None of the above

5. The automobiles release 3, 4-benzpyrene, which causes:
(a) Leukemia [✓ (b) Lung cancer]
(c) Typhoid (d) Hypertension

6. Soil moisture is expressed in terms of:
(a) pH [✓ (b) pF]
(c) P_q (d) Q_{10}

7. The instrument used to measure temperature of water at a particular depth is:
[✓ (a) Thermistor] (b) Thermometer
(c) Thermograph (d) Thermohygrograph

8. With 1° change of latitude on north of equator, mean temperature of atmosphere decreases :
(a) About 1°F [✓ (b) About 10°F]
(c) About 13°F (d) About 0.5°F

9. Photochemical smog is formed by:
(a) NO_X
(b) Hydrocarbons
(c) NO_X and hydrocarbons
[✓ (d) UV-rays upon NO_X and hydrocarbons.]

10. 'Water logging' occurs in which soil?
[✓ (a) Clayey] (b) Sandy
(c) Loamy (d) None of these

11. pF = 0, represents:
(a) Soil temperature as 0°
[✓ (b) Soil is saturated]
(c) Soil at permanent wilting %
(d) Neutral soil

12. The particle size between 0.002–0.02 mm represents:
(a) Clay soil (b) Fine sand
[✓ (c) Silt] (d) Coarse sand

13. Most fertile horizon is:
(a) O-horizon [✓ (b) A-horizon]
(c) B-horizon (d) C-horizon

14. Jet aerosols contain .... which destroys O_3-layer:
[✓ (a) Chlorofluorocarbon] (b) Methyl Isocyanate
(c) Phosgene (d) High sound intensity

15. DDT causes pollution of:
(a) Air (b) Air and soil
(c) Water and soil [✓ (d) Air, water and soil]

16. Diatoms are commonly:
(a) Benthos [✓ (b) Planktonic]
(c) Nektons (d) Neuston

17. 'World Earth day' is celebrated on:
(a) 22nd June (b) 22nd February
(c) 22nd April (d) 22nd May

18. Which plant is completely root less?
(a) *Azolla* (b) *Hydrilla*
(c) *Eichhornia* [✓ (d) *Ceratophyllum*]

19. *Eichhornia* is hydrophyte:
[✓ (a) Free floating] (b) Rooted emergent
(c) Rooted floating (d) Rooted submerged

20. 'True Xerophytes' are:
(a) Ephemerals (b) Succulents
[✓ (c) Non-succulents] (d) All of these

21. Maximum rate of productivity is of:
(a) Tropical grasslands [✓ (b) Tropical forests]
(c) Temperate forests (d) Croplands

22. Height of forests is measured by:
(a) Typsometer (b) Hypsometer
(c) Altimeter (d) Cypsometer

23. Riparian erosion refers to:
(a) Wind erosion (b) Water erosion
(c) Gully formation [✓ (d) Stream bank erosion]

24. 'IBP' stands for:
(a) Indian Botanical Programme
(b) International Botanical Programme
[✓ (c) International Biological Programme]
(d) Biotic Indian Potential

25. Grasslands occupy what percentage of earth's surface?
(a) 14% [✓ (b) 19%]
(c) 10% (d) 30%

26. Ecological Niche is normally occupied by:
[✓ (a) Population] (b) Community
(c) Competing species (d) Competing genera

27. Palisade parenchyma is very well developed in:
(a) Sciophytes [✓ (b) Heliophytes]
(c) Both (a) and (b) (d) None of these

28. Endotrophic mycorrhiza is found in:
(a) Pines (b) Oaks
[✓ (c) Orchids] (d) Beech

29. 'Calcifuges' are the plants growing in:
(a) High Ca [✓ (b) Low Ca]
(c) High pH (d) None of these

30. 'Biocoenosis' means:
(a) Ecosystem [✓ (b) Community]
(c) Ecology (d) Vegetation

31. Estuary is:
(a) Ecade (b) Ecotype
(c) Ecotone (d) Ecophene

32. An interaction favourable to both populations, but no obligatory to either is:
(a) Mutualism (b) Commensalism
(c) Protocooperation (d) Predation

33. Alpine vegetation represents:
(a) Mesotherms (b) Hekistotherms
(c) Microtherms (d) None of these

34. Grasslands with scattered trees and shrubs at wide intervals are:
(a) Steppes (b) Savannah
(c) Prairies (d) Deciduous

35. Rhododendrons are characteristic of:
(a) Evergreen forests (b) Deciduous vegetation
(c) Alpine vegetation (d) Coniferous vegetation

36. The soil below coniferous and alpine vegetation is:
(a) Solonetz (b) Latosols
(c) Podsols (d) Gleys

37. Shallow water region of a fresh water body (as lake) is called:
(a) Littoral zone (b) Limnetic zone
(c) Profundal zone (d) None of these

38. Ecosystem is normally a:
(a) Closed system
(b) Open system
(c) Sometimes open, sometimes closed
(d) None of the above

39. Pyramid of number in forest ecosystem is:
(a) Errect (b) Inverted
(c) Intermediate (d) Any one of these

40. Inhibition of growth of plants by release of certain chemicals by higher plants is called:
(a) Antibiosis (b) Allelopathy
(c) Predation (d) None of these

41. Minamata disease is caused by:
(a) Hg pollution (b) Pb pollution
(c) Sewage pollution (d) Green house effect

42. Genetically fixed variations in a species constitute:
(a) Ecades or ecophenes (b) Ecotypes
(c) Ecotone (d) None of these

43. Upper oxygen rich and comparatively warmer layer of a fresh water body is called:
(a) Limnetic zone (b) Epilimnion
(c) Hypolimnion (d) Aphotic zone

44. Which of the following is not a non-biodegradable substance?
(a) Sewage (b) DDT
(c) Aldrin (d) Chlorinated hydrocarbons

45. Which of the following possess maximum energy?
(a) Producers (b) Primary consumers
(c) Secondary consumers (d) Decomposers

46. Lichens are main indicator of:
(a) Water pollution (b) SO_2 pollution
(c) Radioactive pollution (d) Soil pollution

47. Which of the following is correct sequence of a lithosere?
(a) Foliose lichens → Crustose lichens → Fruticose lichens → Shrubs
(b) Crustose lichens → Fruticose lichens → Moss stage → Foliose lichens
(c) Crustose lichens → Foliose lichens → Fruticose lichens → Moss stage
(d) None of the above

48. Which of the following is a 'malacophyllous' xerophyte?
(a) *Aloe vera* (b) *Euphorbia*
(c) *Opuntia* (d) All of these

49. Which is the indicator of water pollution?
(a) *Chara* (b) *Wolffia*
(c) *E. coli* (d) All of these

50. 'Van Mahotsava' was started by:
(a) Sir Richard Barbe Baker
(b) K.M. Munshi
(c) Sunder Lal Bahuguna
(d) G.B. Pant

51. A group of similar or dissimilar species growing together under more or less similar environmental conditions is called:
(a) Population (b) Community
(c) Vegetation (d) None of these

ANSWERS

1—b	2—a	3—b	4—c	5—b	6—b	7—a	8—b	9—d	10—a	11—b	12—c
13—b	14—a	15—d	16—b	17—c	18—d	19—a	20—c	21—b	22—b	23—d	24—c
25—b	26—a	27—b	28—c	29—b	30—b	31—c	32—c	33—b	34—b	35—c	36—c
37—a	38—b	39—b	40—b	41—a	42—b	43—b	44—a	45—a	46—b	47—c	48—a
49—d	50—b	51—b									

UNIT-8

ASSERTION AND REASON TYPE QUESTIONS

In the questions given below, two statements—an Assertion (A) and a Reason (R) are given. Give the appropriate response as:

(a) If both A and R are true and R is the correct explanation of A.
(b) If both A and R are true and R is not correct explanation of A.
(c) If A is true but R is false.
(d) If both A and R are false.
(e) If A is false but R is true.

1. **A :** Zone of transition between two types of communities is called ecotone.
R : Estuary is an ecotone between marine and fresh water communities.

2. **A :** Productivity at consumers level in called primary productivity.
R : Primary productivity in excess to that which is utilized in respiration and other metabolic activities is called net primary productivity.

3. **A :** Light is important ecological factor.
R : Light affects different physiological processes of plants.

4. **A :** Different metabolic activities of plants are affected by temperature.
R : Different metabolic activities are controlled by enzymes.

5. **A :** Gaseous cover over the earth surface is called environment.
R : Earth's atmosphere is upto height of 300 km.

6. **A :** In stratosphere zone of earth's atmosphere, temperature increases upto 90°C.
R : In this zone, ozone layer is formed under the influence of UV-rays.

7. **A :** Ecological factors connected with physical geography of earth are called topographic factors.
R : Topographic factors are direct ecological factors.

8. **A :** Sandy soils are physiologically dry soils.
R : Water logging occurs in sandy soils.

9. **A :** Soil water available to plants is chresard.
R : Capillary water is only form of soil water which is available to plants.

10. **A :** Laterite soil is reddish brown in colour.
R : There is excess of iron and aluminium in surface horizons of laterite soil.

11. **A :** Ash coloured soil found in cool humid regions is called podsol.
R : Leaching away of Fe, Al and carbonates occurs to deeper horizons in podsols.

12. **A :** An association in which only one organism is benefitted and neither is harmed, is called commensalism.
R : There is no physiological exchange between these organisms in commensalism.

13. **A :** Epiphytes absorb moisture from atmosphere.
R : Aerial roots present in epiphytes have hygroscopic velamen tissue.

14. **A :** Carnivorous plants grow in marshy conditions where there is lack of nitrogen.
R : They catch small insects by some special adaptations in them.

15. **A :** Intraspecific competition is most severe.
R : Organisms of same species have same basic requirements.

16. **A :** System arising out of interactions between living and non-living components of environment is called ecosystem.
R : Ecosystem is normally an open system.

17. **A :** In ecological pyramids, producers occupy the apex of pyramids and top consumers occupy the base.
R : Pyramids of number and biomass may be upright or inverted but pyramid of energy is always upright.

18. **A :** Energy flow in ecosystem is bidirectional.
R : Energy goes on increasing with each and every trophic level.

19. **A :** Non-succulents are the true xerophytes.
R : These xerophytes face both external and internal dryness.

20. **A :** In *Opuntia*, stem is modified into flattened leaf like structure called phylloclade.
R : Leaves in *Opuntia* are modified into spines.

21. **A :** In mangrove plants, branched, negatively geotropic roots come out of the mud, called pneumatophores.
R : Mangrove plants grow in water-logged marshy conditions so there is problem of aeration in roots of these plants.

22. **A :** In hydrophytes, aerenchyma is lacking.
R : Mesophyll tissue is well differentiated into palisade and spongy parenchyma in hydrophytes.

23. **A :** Halophytes are a kind of xerophytes.
R : Halophytes grow in saline conditions and thus face physiological dryness.

24. A : Lichens are the first plants to survive in SO_2 polluted environment.
R : Lichens act as indicators of SO_2 pollution.
25. A : Rill erosion is caused by running water.
R : There is no biological method for soil conservation.
26. A : Chipko movement was started by K.M. Munshi.
R : K.M. Munshi is called tree saint in India.
27. A : The basal portions of stalks of herbaceous plants left in soil after harvesting are called mulches.
R : These mulches are responsible for soil erosion.
28. A : Long chain phenolic compounds, glass, plastics and pesticides like DDT, etc., are persistent pollutants.
R : These pollutants or wastes are not decomposed naturally or by activity of micro-organisms and thus are not recycled back into the atmosphere.
29. A : Automobiles account for 60% of air pollution.
R : Fly-ash is not present in automobile exhaust.
30. A : HF is an air pollutant which is released in ceramics industry and aluminium refinery.
R : Low concentration of HF causes a disease called fluorosis.
31. A : Chemicals released in atmosphere with force in the form of mist or vapours are called aerosols.
R : Jet aeroplanes release aerosols, which contain CFC.
32. A : Increase in global temperature is called green house effect.
R : Green house effect is mainly due to increase in SO_2 concentration.
33. A : DDT is biologically magnified.
R : DDT causes only air pollution.
34. A : Degree of water pollution is measured in terms of BOD.
R : BOD value is low when water is highly polluted.
35. A : Excessive use of nitrogen fertilizers is responsible for Minamata disease.
R : Minamata disease was first reported in town Minimata of Japan.
36. A : Sound above 80 dB is termed as noise.
R : Noise pollution causes nervousness, high blood pressure and short temperness.
37. A : Ultimate hazard to mankind is radioactive pollution or radioactivity.
R : Chief source of radioactive pollution is nuclear-explosions.
38. A : For controlling air pollution, automobiles are fitted with catalytic converters.
R : Catalytic converter converts CO and harmful hydrocarbons into CO_2 and water vapours.
39. A : Maximum biodiversity on land is shown by temperate deciduous forest biome.
R : Multistoried vegetation is characteristic of Savannah biome.
40. A : Deserts show poor biodiversity and their productivity is minimum.
R : Desert plants show phenomenon of allelopathy.
41. A : Grasslands with scattered trees and shrubs are called Savannahs.
R : The termites are one of the most important soil organisms in Savannah.
42. A : Taiga encircles the top of the world.
R : Permafrost is characteristic of taiga biome.
43. A : The crown fires are most destructive as they burn the tree top also.
R : Due to crown fires the temperature of that area may rise even upto 700°C. (AIIMS 1995)
44. A : Xerophytes are adapted to reduce the rate of transpiration.
R : Wax, resin and suberin coating on the surface of plant parts reduce the rate of transpiration. (AIIMS 1996)
45. A : Stomata are not present in submerged hydrophytes.
R : Respiration occurs by means of air chambers in submerged plants. (AIIMS 1997)
46. A : In a food chain members of successive higher levels are fewer in number.
R : Number of organisms at any trophic level depends upon the availability of organisms which serve as food at the lower level.
47. A : Tropical rain forests are disappearing fast from developing countries such as India.
R : No value is attached to these forests because these are poor in biodiversity.

ANSWERS

1. (b)	2. (e)	3. (a)	4. (a)	5. (e)	6. (a)	7. (c)	8. (d)	9. (b)	10. (a)
11. (a)	12. (b)	13. (a)	14. (a)	15. (a)	16. (b)	17. (e)	18. (d)	19. (a)	20. (a)
21. (a)	22. (d)	23. (b)	24. (e)	25. (c)	26. (d)	27. (c)	28. (a)	29. (b)	30. (c)
31. (b)	32. (c)	33. (c)	34. (c)	35. (e)	36. (b)	37. (b)	38. (a)	39. (d)	40. (b)
41. (b)	42. (d)	43. (a)	44. (b)	45. (b)	46. (d)	47. (c)			

UNIT-9

- Applications of Biology (Biology in Human Welfare)
- Test Paper—Unit–9
- Assertion—Reason Type Questions (Unit–9)

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Applications of Biology (Biology in Human Welfare)

- Pesticides and biological pest control
- Biofertilizers
- Domestication of plants and crop plants improvement
- Transgenic plants/crops
- Genetically modified foods
- Genetic conservation
- New and under-utilized crops
- Bioenergy
- Biotechnology
- Biopatent
- Biopiracy
- Biotechnology and sustainable agriculture
- Bio-war.

PESTICIDES AND BIOLOGICAL PEST CONTROL

Pesticides

Pesticides are the chemical substances which kill pests, *i.e.*, epidemic disease producing organisms (like insects, fungi, weeds, nematodes, rodents, bacteria, etc.). Thus pesticides include insecticides, fungicides, weedicides, nematicides, rodenticides, bacteriocides, etc. Pesticides may also be called **biocides**, as most of the pests are living.

Pests cause loss of agricultural productivity upto about **30%** and thus use of pesticides becomes necessary.

- First pesticide to be used commercially is **Bordeaux mixture** ($CuSO_4 + Ca(OH)_2 + H_2O$), discovered by **Millardet** (1882).

On the basis of their chemical nature, pesticides are of following types :

1. Organochlorines : These are chlorinated organic compounds with many chlorine atoms in a single molecule. Some important organochlorines are **BHC** (Benzene hexachloride), **DDT** (Dichloro diphenyl trichloroethane), **Aldrin, Dialdrin, Endosulphan,** etc. These are **non-biodegradable** and hence are biologically magnified.

- **DDT** is the most important (famous) pesticide of the world and **BHC** is the most commonly used pesticide in India. Its concentration in flesh of Indian population is **11–30 ppm.**

Organochlorines have much affinity with fatty tissues of the animals (**lipophillic**) and hence are present in high concentration in fatty tissues of herbivores.

2. Organophosphates : These are organic esters of mostly phosphoric and triphosphoric acids. Important organophosphates used are **Malathion, Parathion, Fenitrothion, Trithion, Ethion, TEPP** (Tetraacetyl pyrophosphate), etc.

- **Malathion is the important and active constituent of flit and is used in large scale control of malaria**

Organophosphates have strong effect on nervous system of insects and thus kill them by paralysing their nervous system. These interfere with conduction of nerve impulses in nervous system.

3. Carbamates : These are derived from carbonic acid in which hydroxyl group is replaced by —NH_2 (amino) group, to form **carbamic acid** (salts of carbamic acid are carbamates). Important carbamates are: **Carbofuran** (furadon), **Aldicarb** (Temik), **Propoxur** (Baygon), **Carbaryl**, etc.

- MIC (Methyl isocyanate) is the raw material for these pesticides.

The carbamates are structurally similar to **acetyl choline** and thus have great affinity for enzyme **acetyl choline esterase.** Carbamates are effective **insecticides** and their derivatives like **phenyl carbamates** are used as **herbicides** and **dithiocarbamates** are used as **fungicides.**

4. **Pyrethoids :** Pyrethrin is an insecticide obtained from floral heads of *Chrysanthemum cinerarifolium* and *C. marschallii* (fam. Asteraceae). Pyrethoids are the synthetic derivatives of pyrethrin.

- Pyrethoids are largest group of insecticides of plant origin, used commercially nowadays.

5. **Triazines :** This group of pesticides is derived from urea. Important triazines are Atrazine, Simazine, etc. These are being commonly used as herbicides in controlling weeds in tobacco, tea and cotton plants.

- Most of the herbicides have effect on photosystem-II of photosynthesis and also disturb translocation of organic food.
- **Bordeaux mixture** is a **fungicide** (antifungal pesticide), discovered by **Millardet.** It is having $CuSO_4$ (40 g), $Ca(OH)_2$ (40 g) and H_2O (5 litres). It is one of the important pesticides used in India.

Advantages of pesticides

1. Increase in yield of food and other crop plants.
2. Pesticides control vectors or carriers of different disease producing organisms.

Harmful effects (hazards) of pesticides

1. As pesticides are **non-selective** in their mode of action, so these also kill useful organisms along with harmful and thus equilibrium state of ecosystem is disturbed.

2. As pesticides are poisonous or toxic, so cause serious health hazards.

3. Excessive and prolonged use of pesticides lead to resistance in pests. Hence more money is to be spent in controlling these resistant pests (this effect is called **pesticide treadmill**).

4. Due to their non-biodegradable nature, these are biologically **magnified** in successive trophic levels, which disturb food webs and cause environmental pollution.

Biological pest control

Due to harmful effects of pesticides on organisms, some alternative methods of pest control are being used and **biological pest control** is one of the suitable methods, *i.e.* use of other organisms to kill the pests constitutes biological pest control and such organisms are called **biopesticides** (*e.g.*, bioherbicides, bioinsecticides, etc.).

Bioherbicides

The first bioherbicide is **devine**, which is a mycoherbicide, based on fungus *Phytophthora palmivora.* It is being used since 1981 to control *Morrenia odorata* (milkweed vines) in *Citrus* orchards. Similarly **collego** is another mycoherbicide from conidia of *Colletotrichum gloeosporioides* fungus.

Bioinsecticides

These include:

(i) **Use of parasites, predators and pathogens :** *e.g.*, control of **aphids** by use of praying mantis or lady bug, *i.e.*, *Mantis.* Similarly insects affecting maize, cotton, cabbage, sunflowers, etc., are controlled by mutant strains of *Bacillus thuringiensis* (*Bt*) bacteria (**sporeine**)

- By use of lady bugs or praying mantis, aphids (plant bugs or homopterous insects) can be kept under control. Fluted scale insect (*Icerya purchasi*), a pest on *citrus* can be effectively controlled by lady bird beetles. Similarly mosquito larvae can be easily controlled by fish *Gambusia* and sugar cane scale insects are controlled by coccinellid predators.
- Prickly pear cactus (*Opuntia*) in Australia and India was effectively controlled by larvae of *Cactoblastis cactorum* (Cochineal insect).

(ii) **Use of insect hormones (Sex attractants) :** The insect hormones called pherohormones (Pheromones) are useful in controlling insects. These pherohormones attract opposite sex insects during breeding season. The natural and synthetic pherohormones are now used to attract the insects towards death traps. The **Orient-fruit fly** has been eradicated by this method. Similarly, **gipsy moth,** a pest of conifers can be trapped.

- **'Confusion technique'** is a variation of this approach and it involves use of pheromones or sex attractants. In this technique, hydrophobic paper having pheromones or sex attractants is placed over the crop area, due to which characteristic smell is spread over the whole field and thus males are unable to locate the females.
- Use of insect hormones like juvenile hormone and molting hormone or ecdysone is also made as bioinsecticides. Juvenile hormone should be present in early stages of growth to prevent early maturation, but if the same is given artificially at later stage of growth, the insect is transformed into giant larva (immature adult) which dies quickly. Similarly, periodic shedding of insect cuticle (molting occurs during the process of growth and ecdysone) hormone is associated with molting. Use of this hormone at inappropriate time also results in early death of insect.

(iii) **Sterilization technique :** This is a modern method of biological pest control. In this technique, male insects are sterilized by irradiation, these are released at the time of mating and hence their multiplication is checked, *e.g.*, **screw worm** (*Cochliomyia hominivorax*) and **red weavil** (a pest on coconut) have been checked by this method.

(iv) **Use of natural insecticides :** The insecticides of plant or micro-organisms origin are called **natural insecticides.** These have little toxicity for animals, *e.g.*, **Rotenone** (from roots of *Derris* sps. and *Lonchocarpus* sps.); different alkaloids like **Nicotine** (from **tobacco**), **Pyrethrum** and **Cinerin** (from *Chrysanthemum*); **Azadirachtin** (from *Margosa* or Neem) are useful natural insecticides.

- Neem or margosa (*Azadirachta indica*) is most useful natural insecticide. It is resistant to about 200 species of insects, nematodes, mites, etc.

Integrated Pest Management (IPM)

IPM involves use of different pest control methods, which are **ecologically sound** (*i.e.*, not cause hazard to environment), *e.g.*, **biological control methods, better agricultural practices** like crop rotation, sanitation, etc., **starvation method,** *i.e.*, growing of target crop away from major crop, **ultra low volume spraying method,** *i.e.*, use of very low and most effective concentration of chemicals, which does not cause pollution, etc.

BIOFERTILIZERS

Use of chemical fertilizers and pesticides in the recent past has increased food production enormously. But side by side, there are many hazardous effects of these chemical substances on environment and organisms besides highly expensive. So, use of fertilizers of biological origin is an alternative for overcoming the harmful effects of these chemical fertilizers. These fertilizers of biological origin are called **biofertilizers.** These provide the essential elements to the soil and hence maintain or increase the soil fertility. Use of these biological fertilizers is safe both economically as well as ecologically.

There are two main categories of fertilizers of biological origin:

(A) Green manures
(B) Biofertilizers

(A) Green manures

These are fast growing herbaceous crops which are ploughed down and mixed with the soil while still green for enrichment of soil. These provide both organic matter and nitrogen to the soil, in which Indian soils are generally poor. The green manure **checks soil erosion** by forming protective soil cover and also **prevents leaching.** Increase in yield by 30–50% has been observed by use of green manures.

Some important **green manure crops,** which are mostly members of family **Leguminosae** are as follows:

(i) *Crotolaria juncea* (Sunhemp or Sunn)
(ii) *Sesbania sesban* (Dhaincha)
(iii) *Lens esculenta* (Lentil or Masur)
(iv) *Cyamopsis tetragonoloba* (Guar or Cluster bean)
(v) *Dolichos biflorus* (Horse gram or Kulthi)
(vi) *Melilotus parviflora* (Senji)
(vii) *Vigna sinensis* (Lobiya or Cowpea)
(viii) *Trifolium alexandrianum* (Barseem or Egyptian clover)

(B) Biofertilizers

These are the organisms (like bacteria, blue-green algae or fungi) which enrich the soil in nutrients. Some of the important biofertilizers are:

1. Bacteria as biofertilizers

(i) Symbiotic Nitrogen-fixing bacteria : *Rhizobium leguminosarium* bacteria live symbiotically in root nodules of legumes and some non-legumes, which fix atmospheric N_2 and hence increase the fertility of soil.

(ii) Free-living Nitrogen-fixing bacteria : Some bacteria like *Azotobacter* (aerobic), *Clostridium* (anaerobic), *Rhodospirillum, Chromatium* (photosynthetic bacteria) are free living nitrogen fixing bacteria of soil, which increase fertility of soil and hence yield of crop plants.

(iii) Loose association of Nitrogen-fixing bacteria : A bacterium *Azospirillum lipoferum* forms loose association with roots of maize and some Brazilian grasses (Dobreiner, 1975), which increase the crop yield upto a large extent.

2. Blue-green algae (Cyanobacteria) as biofertilizers

(i) Free living Nitrogen-fixing blue-green algae : Blue-green algae like *Nostoc, Anabaena, Aulosira, Tolypothrix, Plectonema* and *Cylindrospermum* are the most common nitrogen fixing organisms, probably with the help of heterocysts. Photosynthesis provides the energy for nitrogen fixation. In the rice fields, *Aulosira* is the most active nitrogen fixing blue green alga. It is estimated that 7-8 lakh tons of nitrogen can be fixed by blue-green algae, thus saving 15–17 lakh tons of urea every year.

(ii) Symbiotic Nitrogen-fixing blue-green algae : *Anabaena azollae, Anabaena cycadacae* and *Nostoc punctaeformae* are present symbiotically in leaves of *Azolla* (water fern), *Cycas* roots and *Anthoceros* thallus respectively, which fix atmospheric nitrogen. *Azolla-Anabaena* symbiotic system is the main biofertilizer which is inoculated in rice fields in South-Eastern Asia, which is found to increase yield upto 50%.

3. Fungi as biofertilizers

(i) Mycorrhiza : Symbiotic association between roots of higher plants and fungal hyphae, is called mycorrhizal association or mycorrhiza. It is of 2 types:

(a) Ectotrophic or Ectophytic mycorrhiza : Here, fungal hyphae are present on the surface of roots. It increases water and nutrient absorption, growth vigour and yield of plants, *e.g.*, in Pinus, Oak, Eucalyptus, Peach, etc.

(b) Endotrophic or Endophytic mycorrhiza : Here, fungal hyphae are present inside or between the cells of cortex, *e.g.*, in Coffee, Pepper and Cardamon, etc.

In many grasses and some other crops, the fungal hyphae penetrate to the cortical cells, which swell to form **vesicles** or **arbuscules,** called **vesicular-arbuscular mycorrhiza** (VAM). It has significant role in **phosphate nutrition** of plants.

DOMESTICATION OF PLANTS AND CROP PLANTS IMPROVEMENT

Domestication of plants

All the present species of cultivated plants are of wild species origin and this **process of cultivation of wild species** in order to fulfil human needs is called **domestication of plants.** Domestication plays foremost role in development of human civilization. Further effective agriculture is the result of domestication of crop plants. Origin of agriculture dates back to **7000–13,000** years ago in high and well watered lands of Indus, Tigris, Nile and Euphrates. According to **Carl Scanner,** nitrogen loving plants were the first wild weed plants, which were then brought under cultivation. Cultivation of plants started with the help of vegetative parts in the form of tubers, bulbs, rhizomes, etc., but later on ability of seed to develop into new plant was recognized and most of the early civilizations like Babylonian, Egyptian, etc., developed on the basis of seed-generated crops like wheat, rice, maize, barley, etc. (cereals). Actually, the method of obtaining plants from seeds, is known as **cultivation.**

- Origin of cereals actually took place in mountainous parts of both **old world** (Asia, Africa and Europe) and **new world** (America) and present day cereals were infact wild weeds. **Cereals were** actually **the first group of plants,** which were **brought under domestication** because of rapid growth, sufficient amount of reserve food and weediness. After direct food plants like cereals, plants with cooking qualities were brought under cultivation. Discovery of fire was an important reason behind it. So, now different other food plants like pulses, oil seeds along with cereals were discovered and man turned into actual farmer. After discovery of single purpose plants, multipurpose plants were known and these were brought into cultivation, *e.g.*, coconut, date palm, hemp, mulberry, etc.

Origin of cultivated plants

The earliest view of origin of cultivated plants is that these plants are given by God in form of gifts. Later on it was said that wild types converted into cultivated types due to their cultivation under good agronomic conditions. Most important contribution in the problem of origin of cultivated plants was made by a Russian worker called **N. I. Vavilov** (1926), who on the basis of his studies reported that there are eight primary centres of origin of cultivated plants, where all grades of variations from wild type species to cultivated types occur. Further these **primary** centres are dominated by **dominant genes.** In the course of cultivation, the plants spread to different parts of the world. These **Vavilov's 11 primary** centres (or eight) of origin of cultivated plants with their natives are as follows :

I. The Chinese centre of origin : The natives of this oldest and largest centre are Radish, oat, turnip, trapa, brinjal, cucumber, *Citrus*, lotus, etc.

II. The Indian centre of origin : (exclusive of N.W. India, Punjab, Assam, Burma)

Natives are Rice, sorghum, gram, arhar, lobiya, mango, sugar cane, coconut, til, cotton, jute, black pepper, etc.

IIa. Indomalyan centre of origin : Natives of this region are Ginger, banana, jack fruit, black pepper, etc.

III. Central Asiatic centre of origin : Natives of this region are Wheat (*Triticum vulgare, T. compactum, T. sphaerococcum*), European rye, pea, lentil, etc.

IV. Near Eastern centre of origin : (Including Iran and Turkmenistan)

Natives of this region are Wheat (*T. monococcum, T. durum, T. turgidum*), flax, beet, pomegranate, etc.

V. Mediterranean centre of origin : It is centre of origin of Wheat (*T. dicoccum, T. polonicum, T. spelta*), cabbage, onion, peppermint, etc.

VI. The Abyssinian centre of origin : (Ethiopia and Somalia). The natives are-Barley, pearl-millet, sesame (til), coffee, lady's finger, etc.

VII. South Mexican and Central American centre of origin : Maize, sweet potato, pepper, upland cotton, guava, cocoa, tobacco, etc.

VIII. South American centre of origin : Maize, tobacco, *Solanum andigenum* and *Phaseolus lunatus*.

VIIIa. The Chile centre of origin : Potato.

VIIIb. The Brazilian centre of origin : The natives of this region are-Groundnut, hevea rubber, cashewnut, cassava and pine apple, etc.

Crop plants improvement

The applied branch of Botany, which deals with improvement of agricultural crop plants is called **Plant breeding.** This is rather a new branch of Botany. Plant breeding may be defined as, "the branch which deals with improvement in heredity of crops and production of new crop varieties, which are superior to earlier ones in all respects". This superiority or improvement may be in following respects:

(i) Quantitative characters : Increase in yield of seeds, grains, fibres, oils, etc.

(ii) Qualitative characters : Increase in biochemical components as well as taste, milling, baking, cooking, etc.

(iii) Resistance to diseases, insects, pests, drought, frost, cold, lodging, etc.

(iv) Earliness or lateness in maturity period or change in maturity behaviour.

(v) Adaptability to wider range of conditions, etc.

Important plant breeders

(i) N.I. Vavilov : Famous Russian plant breeder, who gave centres of origin of cultivated plants.

(ii) N. E. Borlaug : Famous Mexican plant breeder, who was awarded **Nobel Peace Prize** (1970) for developing high yielding dwarf wheat varieties like **Sonora-64, Lerma rojo-64**, etc. He is known as **'Father of green revolution'.**

Indian plant breeders

(i) Sir T.S. Venkatraman : Pioneer Indian plant breeder famous for sugar cane improvement.

(ii) Choudhary Ram Dhan : Wheat breeder, who is famous for C-591 variety of wheat, which made Punjab as wheat granary of India.

(iii) Dr. B. P. Pal : Famous wheat breeder, who produced many NP wheat varieties.

(iv) Dr. K. Ramiah : Famous rice breeder of international fame.

(v) Dr. Puskar Nath : Famous potato breeder.

(vi) Dr. Boshi Sen : Famous maize breeder.

(vii) Dr. M.S. Swaminathan : He is pioneer mutation breeder. He has produced Sharbati Sonora variety of wheat by mutation, which is responsible for green revolution in India. Dr. Swaminathan is called **'Father of green revolution in India'.**

Crop improvement means combining all the good characters in a single plant and multiplying them. The main aim of the plant breeder is to produce new superior crop varieties. The main methods of crop improvement are:

1. Selection
2. Hybridization
3. Polyploid breeding
4. Mutation breeding
5. Plant introduction and acclimatization
6. Tissue culture
7. Genetic engineering

1. Selection : This is the most primitive and simplest method of crop improvement.

Selection is basically of 2 types:

(i) Natural selection : This occurs in nature and has resulted in evolution. This is based on **Darwin's theory of survival of fittest**, *i.e.*, best survives and rest perish.

(ii) Artificial selection : This is practised in crop improvement and it is selection of phenotypically superior plants from a mixed population. It is further of following types:

(a) Pure line selection : The progeny of a single self-fertilized homozygous plant is called pure line and these pure lines are used in selection method of crop improvement which is called pure line selection (Johannsen).

- o Pure line selection is method of improvement in self-pollinated plants.

Here, number of phenotypically superior plants are selected, these are harvested separately and their produce is maintained separate. The seeds so obtained from different plants are sown separately and selection is made for 4 or 5 generations till the desired improvement is achieved. About 10 years time is needed to develop a new variety by this method.

(b) Mass selection : This is practised in cross **pollinated plants.** Here, number of superior looking plants are selected from mixed population, harvested and their produce is combined together, *i.e.*, **enmassed,** which is sown in next year and then selection is made in similar manner. It is done for 5 to 6 generations or more till desired improvement is achieved. It takes about 8 yrs. time to develop a new variety by mass selection.

(c) Clonal selection : Progeny of a single vegetatively propagated plant is called clone. Clonal selection is used as method of improvement in vegetatively propagated plants. Here, selection is made between the clones and not within the clone.

2. Hybridization : This is an important method of combining together characters of different plants and it is defined as, "crossing of two plants of unlike genetic constitution". The primary aim of hybridization is to produce variations. Hybridization doesn't change genetic contents of organisms but it produces new combination of genes.

- First natural hybridization was reported in corn (maize) by **Cotton Mather** (1716).
- First **artificial hybrid** was obtained by crossing sweet **william** and **carnation** by **Thomas Fairchild** (1717) and was known as **Fairchild's Mule.**
- Hybridization was first of all practically utilized in crop improvement by **Kolreuter** (1760).

Hybridization may be of different types as intravarietal, intervarietal (intraspecific), interspecific (intrageneric) and intergeneric (distant hybridization).

- Hybridization or crossing leads to **Hybrid vigour** or **Heterosis,** which is defined as superiority of hybrid over its parents.
- The term heterosis was given by **G. H. Shull** in 1914 (*Heteros*—different + *osis*—condition), *i.e.*, different condition of hybrid from its parents.

(Selfing results in depression)

Hybrid vigour has been commercially exploited in different commercial crops like **maize, sorghum, bajra, tomato, sugar beet, petunia, zinnia and cucumbers.** The hybrid vigour is lost after few generations.

The main steps of hybridization are:

(a) Selection of parents

(b) Selfing of parents to induce homozygosity.

(c) Emasculation, *i.e.*, removal of anthers or male reproductive part from flowers of female parent before maturity or before anthesis (*i.e.*, first opening of flower) or before bursting of anthers.

(d) Bagging : Male and female flowers are covered with bags so that no undesirable pollen may fall on stigma.

(e) Crossing of desired and selected plants.

(f) Seed setting and harvesting.

Thus, 2 main aspects of hybridization are :

(i) To combine characters of two plants into one.

(ii) To utilize hybrid vigour.

3. Polyploid Breeding : The organism (plant) which contains more than two complete sets of chromosomes, is called **polyploid.**

Depending upon number of chromosomal sets, the individuals are given different names as:

Monoploids, diploids, triploids, tetraploids, pentaploids and hexaploids (*e.g.*, wheat)

- Polyploids are characterized by **gigantism** or increase in cell size and hence organ size and thus overall size. These polyploids are used in crop improvement, *e.g.*, triploids are present naturally in different crop plants and generally in triploids, seedlessness is present. Most of the varieties of banana are triploids and hence their fruits are seedless. These triploids are not of any use in such plants where seeds are of commercial importance. In sexually reproducing organisms polyploidy is induced as a result of fusion of egg with more than one male gametes.

Polyploidy can also be induced artificially by **colchicine treatment.** Colchicine is an alkaloid obtained from *Colchicum autumnale* (Liliaceae).

- In some plants triploids are having much vigour and increased fruit size, *e.g.*, apple and pear. Similarly in triploid sugar beet, increased size of roots is present.

4. Mutation Breeding : Hugo devries was the first person who defined mutation as sudden phenotypic changes which are heritable.

- But nowadays mutations are used in strict sense to cover only changes in the chemical structure of gene at the molecular level and it is specifically known as **gene mutation** or **point mutation.** Near about 1960, it was felt that mutations can be used in crop improvement.
- Mutations are **spontaneous** as well as **induced,** *i.e.*, can be artificially induced by certain mutagens or mutagenic agents.

These mutagens are of 2 types:

(a) Physical mutagens, *e.g.*, X-rays, β-rays, γ-rays as well as UV-rays.

(b) Chemical mutagens, *e.g.*, nitrous acid, maleic hydrazide, hydrazine, methyl methane sulphonate (MMS), ethyl methane sulphonate (EMS), etc.

- Mutations are generally harmful and recessive. One in 1000 or more mutations may be useful and these useful mutants have no rival.
- Many important varieties in different crop plants have been produced by mutation breeding and some important ones are :

In Wheat : Sharbati Sonora and **Pusa lerma** are the two important varieties of wheat produced by gamma rays treatment of Sonora-64 and Lerma Rojo-64 (Mexican dwarf wheat varieties).

Sharbati Sonora is amber grain coloured variety of wheat produced by Dr. M.S. Swaminathan and is responsible for green revolution in India.

In Rice : About 45 varieties upto 1992 have been produced by mutation breeding. Important ones are: **Remei** variety and **atomita-2.**

In Barley : Erectoids and **Erectiferum** varieties have been produced.

In Castor : World famous variety **Aruna** has been produced in which life span has been reduced from 270 days to 102 days and also having high oil content and disease resistance.

In Peppermint : Todd's Mitcham variety, which is highly disease resistant and with high oil content.

Penicillin production has been increased enormously by UV-rays treatment of *Penicillium notatum* and *P. chrysogenum.*

Besides these a large number of other varieties have been produced in various crop plants.

Mutation breeding has some important limitations as :

(i) Most of the induced mutations are invaluable to the breeders and many of them are lethal.

(ii) Mutation rate is extremely low.

(iii) Stability of mutants is sometimes doubtful as some mutants have tendency to revert back to original type.

(iv) Most of the mutations are recessive.

5. Plant Introduction and Acclimatization : This is most rapid and easiest method of crop improvement. **Plant introduction** is the process of introduction of plants from their growing locality to another with changed climatic conditions.

Acclimatization means adaptation of introduced or transferred plant in the changed or new climatic conditions. If there is no acclimatization, introduced plant will perish.

The purpose of introduction may be genetic improvement of crops, use in agriculture and forestry, study of origin, distribution, classification and evolution of plants and also for aesthetic interest.

There is a definite procedure for introducing a plant material from abroad and strict plant protection and quarantine laws have been made. If the plant material is found suitable, phytosanitary certificates are issued and only then the plant material is introduced in our country.

Uncontrolled plant introduction in the past are responsible for introduction of hazardous diseases (like **late blight of potato, flag smut of wheat, leaf rust of coffee, fire blight of apple and pear, bunchy top of banana,** etc.), weeds (*Argemone mexicana, Lantana camara, Eichhornia crassipes* and *Parthenium argentatum,* etc.) and many insect pests.

But achievements of plant introduction are also numerous, *e.g.,* **new plants** like maize, potato, groundnut, chillies, coffee, rubber, guava, grapes, papaya, cashewnut, litchi, loquat, cassia, quisqualis, gulmohar, bougainvillea, phlox, aster, etc., are the result of plant introductions. Similarly, many improved varieties of different crop plants are also outcome of these introductions, *e.g.,* **Ridley** and **Sonora-64** varieties of wheat, **Kent** var. in oat, **Monetta, Palmetto** varieties in soybeans, **Sioux** var. in tomato, **Bonneville** variety in pea, etc. Further many other improved varieties have been produced from these introduced varieties.

6. Tissue Culture : This is one of the latest and most promising methods of crop improvement in such plants, where all other conventional methods of breeding fail. Tissue culture technique is based on totipotent nature of plant cell or phenomenon of **totipotency,** *i.e.,* each and every plant cell has inherent capacity to develop into complete plant.

The concept of totipotency was given by **Haberlandt** (1902) and practical application of totipotency was shown by **Steward** (1932), when he developed a complete carrot plant from a single cell obtained from root of wild carrot.

In tissue culture technique, a single cell or a group of cells is taken for culture, which is known as **explant.**

By culturing explant in culture medium, an undifferentiated mass of cells is obtained, which is known as **callus** and then by using root initiating and shoot initiating hormones in culture medium, **organogenesis** occurs and thus complete seedling is obtained, which is transferred to the soil for further growth.

- The main uses or applications of tissue culture in crop improvement are:

(i) Micropropagation : Means rapid vegetative multiplication of valuable plant material for agriculture, horticulture and foresty and that is by **shoot meristem culture** and **somatic embryogeny** or **somatic embryoides.**

(Propagation through tissue culture is called micropropagation)

- One of the most important uses of tissue culture technique is reducing the time span.

(ii) Haploid production : The most important method of haploid production is **pollen-culture.** Sometimes diploid plants are formed among haploid plants and source of these diploid plants is anther wall (which is diploid)

- Haploid production through pollen culture was first made in *Datura innoxia* (Jimson weed) by **Guha** and **Maheshwari** (1964).

Haploids are very important in plant breeding because :

(a) They have single set of chromosome, so even a very small change or mutation can be detected in haploids.

(b) These haploids are used to produce **homozygous diploids** (by colchicine treatment) and these homozygous diploids are used as parents in crossing programme.

(iii) **Productin of disease free plants:** This is very important use of tissue culture and disease free plants can be produced by **shoot-meristem culture** as shoot apical meristems are free of pathogens specially viruses.

Using this method healthy plants of potato, sugar cane, sweet potato, dahlia and other ornamentals are produced in routine.

(iv) **Culture of rare hybrids:** In intergeneric and interspecific hybrids, embryo abort at earlier or later stages. By using embryo culture we can save rare hybrids. In this technique, embryo is excised at younger stage and is cultured in culture medium. So, maintenance of rare hybrids is by embryo culture.

(v) **Protoplast culture:** This is one of the most important and latest tissue culture technique. The two important uses of protoplast culture are :

(a) **Somatic hybridization:** The two protoplasts are fused by **PEG** (Polyethylene glycol) and thus somatic hybrids are obtained. The separation of protoplasts is done by treating cells with pectinase and cellulase enzymes. Successful somatic hybrids have been obtained between species of *Brassica, Nicotiana, Petunia* and *Solanum.*

- **Pomato** is a somatic hybrid between tomato and potato and is example of intergeneric hybrid.

(b) **Genetic engineering:** Due to fragile nature of protoplast, certain bacteria, portions of DNA, nitrogen fixation genes (**Nif genes**), etc., can be easily incorporated.

(vi) **Somaclonal variations:** Plants produced through tissue cultures, *i.e.*, from callus have been found to have considerable variability or variations, known as **somaclonal variations.**

The variations which are stable and have agronomic characters (pest and disease resistance, etc.) are useful only.

(vii) **Nucellus culture:** Strictly parental type plants can be obtained through nucellus culture, which is completely free of micro-organisms including viruses. Such plants obtained through nucellus culture maintain their characters for a long time.

(viii) **Cryobiology:** Dry freezed storage of germ plasm is called cryobiology.

7. **Genetic engineering:** This is the latest method of crop improvement in which instead of involving whole chromosomal set (genome), manipulation of a segment of DNA (gene) is done.

In this technique, introduction or deletion of one or more genes is done into an organism or plant. Here, the first step is isolation of a segment of DNA (gene) controlling a particular character. **Restriction enzymes** (endonucleases) are the specific enzymes, which are used to cut DNA at specific sites (hence called **genetic scalpels**). The second step is to transfer the specific DNA segment from one organism to the other. Protoplast is used for this purpose, where microinjection of DNA is done by fine needles. The **third step** involves cloning the DNA. Here, foreign DNA and plasmid DNA are joined with the help of DNA ligase enzyme to give rise to **recombinant DNA** (having additional characters). Now vectors or carriers (like bacterial plasmids, bacteriophages, plant viruses, etc.) are used to carry this recombinant DNA. These carriers are multiplied to obtain **clone of cells** having the same foreign DNA (cloning the DNA). These multiplied foreign DNA (genes) are now transferred to cells of different target crop plants. But this process is not so simple as it appears. It requires complete knowledge of location and functions of different genes in different crop plants. As each crop is having 1–10 million genes, so detailed genone analysis is very complex. Thus genetic engineering or recombinant DNA technology has many problems and obstacles.

TRANSGENIC PLANTS/CROPS

The most important use of plant biotechnology is the production of superior transgenic crops/plants which are having not only the resistance against a variety of biotic and abiotic stresses, but also having some improved value added properties like nutritional quality of food. **Transgenic plants are those plants in which a foreign gene has been introduced and stably integrated into host DNA.** A gene that has been transferred using the tools of molecular biology is called **transgene.** The transfer or introduction of a foreign gene results in syntheis of desirasle traits like **disease resistance, insect resistance, herbicide resistance,** etc.

- Transgenic plants have now been produced in more than 60 plant species (mostly in dicotyledonous families and in some monocotyledonous families also). The **first transgenic plants** were produced in **tobacco** (*Nicotiana tabacum*). Some other higher plants where transgenic plants have been produced are *Petunia hybrida, Lycopersicum esculentum* (tomato), *Solanum tuberosum* (potato), *Solanum melongena* (brinjal), *Lactuca sativa* (lettuce), *Brassica napus* (oilseed rape or canola), *Glycine max* (soybean), *Pisum sativum* (pea), *Beta vulgaris* (sugar beet), *Vitis vinifera* (grape), *Asparagus, Secale cereale* (rye), *Triticum aestivum* (wheat), *Zea mays* (maize), *Avena sativa* (oat) and a gymnosperm *Picea glauca* (white spruce), etc.
- Some of the transgenic plants have been released for commercial cultivation, *e.g.*, 'Flavr Savr' and 'Endless Summer' tomatoes, 'Freedom II' squash, 'high lauric' rape seed or canola, 'Roundup Ready' soybean. Similarly genetically engineered insect resistant potato (New Leaf), corn (Maximizer) and cotton (Boll Gard), each having *Bt* toxin gene from *Bacillus thuringiensis,* have been granted full registration. Transgenic plants/crops are also called **genetically engineered crops** or **GM crops** (genetically modified crops) or GMO (genetically modified organisms).
- Specific gene transfer in plants is mostly done with *Agrobacterium tumefaciens* bacteria (causes crown

gall-disease in many dicots). The tumour causing ability resides in a plasmid called **Ti plasmid** of *A. tumefaciens*. This plasmid has become very important in plant breeding because specific genes can be inserted into the Ti plasmid by recombinant DNA technique and thereby changing the genotype and phenotype of the plant. *A. tumefaciens* based gene transfer is hampered by host range limitations.

- Gene transfer can also be made directly without using biological vectors (plasmids, bacteriophages, etc.). Naked plant cells as protoplasts have been found ideal for vectorless gene transfer. Some vectorless gene transfer methods are:

(a) Gene transfer using particle bombardment (DNA-coated tungsten pallets fired by a 'gene gun'). This technique is being used in monocotyledonous plants.

(b) Microinjection technique
(c) Macroinjection
(d) Lipofection
(e) Silicon carbide fibre-vortex
(f) Ca-DNA co-precipitation method
(g) Electroporation
(h) Ultrasonication

(i) UV-laser microbeam (However, success in few systems).

- Recently, transgenic plants have been explored for production of biologically active peptides and proteins (having pharmaceutical applications including use as vaccines, immunomodulators, growth factors, hormones, blood proteins and enzymes). These proteins and peptides play a key role in production of **edible vaccines and antibodies**, which are convenient and inexpensive for immunotherapy. An edible vaccine against diarrhoea has been expressed in potato and against dental caries in tobacco. Research on transgenic plant-based production of various vaccines and antibodies is in early stages but these generate a hope towards low-cost edible vaccines and antibodies from plants.
- Plant biotechnologists in India have claimed the production of an edible vaccine against cholera in tomato. This tomato will be light bluish in colour and is expected to be in market in next year.
- **Golden rice** or **Miracle rice** (rich in vitamin A or β-carotene and iron) and **decaffeinated coffee** are also valuable achievements of gene transfer technology.

Biosafety of transgenic plants : Nowadays, there is a debate on biosafety issues of transgenic plants. The key points are:

(i) Potential of GM crops to become weeds.

(ii) Opportunities of gene flow from a GM plant to other plants.

(iii) Impact of growing transgenic plants on biodiversity.

(v) Capacity of pest and pathogens to adapt to the cultivation of GM crops.

- Ignoring the risks involved in cultivation of transgenic crops, in China, 2300 hectares of land has been placed under transgenic crops. **In India,** however, onlyone transgenic crop (*Bt*-Cotton) has so far been released for cultivation. Recently in March 2002, Government of India has permitted the commercial cultivation of three varieties of ***Bt*-Cotton,** the first genetically modified crop of the country. This has been developed by **MAHYCO** (Maharashtra Hybrid Seeds Company) in collaboration with American company **Monsanto.** *Bt*-Cotton is resistant to **Boll-worm** disease of cotton.

GENETICALLY MODIFIED FOODS

In the last five years, the area under transgenic crops has increased enormously in USA, China and some other advanced countries. In USA, 35% of corn and 55% of all soybean planted were transgenic in 1999. As soybean and corn are used as ingredients in a wide range of food products, many foods currently contain ingredients derived from genetically engineered or transgenic crops. The area under transgenic crops will continue to rise and thus will result in more food derived from transgenic crops. **The foods derived from transgenic crops are called 'GM foods' or genetically modified foods.**

Health and food safety concerns have been raised to ensure the safety of GM foods throughout the development and commercialization of transgenic crops. The main concerns about the potential of GM foods/crops relate to:

- Increase in toxins
- Introduction of allergens
- Changes in levels of essential nutrients
- Reduced-efficacy of antibiotics.
- Issues of food safety from GM crops came with a 3-years study conducted by **Dr. Arpad Pusztai** at Rowett Research Institute, Scotland in 1999, who showed partial suppression of growth and of development of immune system in rats fed on GM potato.
- **Dr. March Lappe** (1999) showed that certain GM foods (GM soybean) have lower levels of vital nutrients especially phytoestrogen and isoflavones which protect the body from heart diseases and cancer.
- **Nordlee** (1996) reported that Brazilnut (*Bertholletia excelsa*) genes in soya caused epileptic fits. Similarly, **Shrimp gene** in strawberry induced allergic response.
- During early course of development of transgenic crops, a concern was raised that transfer of antibiotic resistance transgene from plants to pathogens in environment or in the gut of humans or animals would compromise antibiotic therapy by rendering pathogens immune to the effects of the antibiotic.
- On the other hand genetically modified crops are being developed with enhanced nutritional qualities such as increased iron (Fe) or vitamin A content in edible plant parts (*e.g.,* 'Golden rice' or 'Miracle rice' rich in vitamin A and iron). Iron fortification of rice has been done by soybean ferritin gene.

- The US food and Drug Administration (USFDA) established extensive guidelines to address the concerns and ensure the safe commercial introduction of GM crops for use in food and feed. These guidelines have been developed through evaluation of scientific data and consultation with experts from around the world. Foods containing GM crops meeting the FDA guidelines are deemed to be as safe and nutritious as their non-GM counter parts already in market.

There have been debates in many countries on whether or not, it should be mandatory to lebel the genetically engineered food. In USA, no such mandatory lebelling has been considered necessary, unless the transgenic food or GM food differs significantly in composition or is allergenic, *e.g.*, tomato having significantly reduced content of vitamin C should be lebelled. Similarly, tomato having a gene from peanut should disclose this as peanut contains allergens. Transgenic canola (oil seed rape) having a gene of Brazilnut (being allergenic) is considered to have no commercial utility and hence should be lebelled for consumers.

- GM food safety guidelines established using current scientific knowledge are not static and will continue to be refined as new knowledge is gained in areas related to food safety.

GENETIC CONSERVATION

This earth is having diversity of plants, which form important genetic resources. Basic necessities of life are fulfilled by these genetic resources and further these are helpful in maintaining the ecological balance. But uncontrolled and unplanned exploitation of this biodiversity by man has hazardous effects on environment and thus conservation of genetic resources is the prime need.

Due to intra and interspecific variations in variety of genes (genetic diversity), improvement of crop plants takes place. But simultaneously as a result of genetic erosion, there is loss of genes from gene pool (totality of genes in a species or population), which leads to reduction in genetic variability. Deforestation, shifting cultivation, urban expansion, disturbances in ecosystems and use of some specific plant varieties are some of the causes of genetic erosion. Following are the fundamental ways for conservation of genetic resources of the plants:

(i) Conservation of plants in wild state, *i.e.*, in natural habitats like forests.

(ii) Conservation of plants in botanical gardens.

(iii) Introduction of plants for cultivation in agriculture and horticulture.

(iv) Preservation of plants in seed form or some other suitable form.

Growing of plants in natural habitats like biosphere reserves, national parks, etc., is called *In situ* conservation and is of great help for genetic conservation.

Similarly, there is another method of genetic conservation, where the rare or selected plant materials are grown in special gardens, which is called *Ex situ* conservation, *e.g.*, *Ginkgo biloba* has been common because of its cultivation in gardens.

Significance of germplasm of wild species

It is very important to conserve wild species of plants as these are highly resistant to insects, pests, diseases and unfavourable growth conditions, which are necessary for survival of plants. The loss of wild plants will reduce the genetic variability and will be a great loss to gene pool. Potato and sugar cane have been improved by use of germplasm of wild species having many defensive characters like disease resistance and resistance to environmental stresses.

In potato (*Solanum tuberosum*), genes for resistance to potato virus-X and potato leaf roll virus have been obtained from a wild species *Solanum ocaule*; resistance to wilt fungus (*Fusarium*) and cyst nematode (*Globodera*) has been introduced from *Solanum spegazzani;* resistance to potato virus-Y has been introduced from *S. stoloniferum* and resistance to late blight of potato (caused by *Phytophthora infestans*) has been derived from *S. demissum*.

Similarly, sugar cane (*Saccharum officinarum*) has been improved with respect to resistance to different fungal and viral diseases by introducing the genes from wild species *Saccharum spontaneum* (Kans).

Gene banks

For plant breeding purpose (*i.e.*, for improvement of plants), a large number of varieties with different characters are needed. Hence number of plants (both wild and cultivated) are collected and stored at suitable place. The place or institution where different plant materials (genes) are kept or preserved, is called a gene bank. In gene bank, storage is done either in the form of seeds or vegetative materials, but best and convenient way is storage of seeds. Storage of dry seeds is done at low temperature (–10 to –20°C), because under these conditions, their metabolic activities are minimum which check their germination. Seeds are of two types:

(a) Orthodox seeds are those which are not killed or damaged as a result of decrease in moisture contents and temperature. These can even live upto –196°C, *e.g.*, seeds of wheat, rice, maize, oat, barley (cereals) and also different pulses or legumes.

(b) Recalcitrant seeds are those which are killed or damaged as a result of drying and decrease in temperature. These can be stored for a short span, *e.g.*, seeds of rubber, tea, coconut, jack fruit (*Artocarpus*), litchi, oil palm (*Elaies*), etc. Conservation of crops with this type of seeds can be made by *In situ* conservation method and also by tissue culture method.

Storage of germplasm by tissue culture

The tissue culture technique for storage of germplasm is used in cases where (a) No seeds are produced (b) Non viable seeds (c) Recalcitrant seeds (d) Seeds are highly variable and (e) Specific clone is to be maintained.

Best method of tissue culture for germplasm storage is **shoot meristem culture.** The main advantages of tissue culture storage of germplasm are:

(a) Economical (b) Requires small area for storage of many genotypes (c) Can be used for multiplication of rare and endangered species.

Cryopreservation : . Dry, freezed storage of germplasm (at –196°C) is called cryopreservation. Under these conditions, there is near stoppage of all biological activities and further there are no chances of genetic changes. This method is not used for plant germplasm.

International efforts for utilization of crop-germplasm

Cereals (rice, wheat, maize, rye, sorghum, bajra, etc.) are the main sources of food for human population in the world and rice alone constitutes staple food of more than 50% world's population.

- In rice, considerable increase in yield has been made by introducing genes for resistance to 'grassy shoot virus' from wild rice (*Oryza nivara*) found in central India. Similarly, introduction of dwarfing genes from a variety of Taiwan, **Dee-geo-woo-gen** has produced many improved varieties in rice. **IR-36** variety of rice has been developed at IRRI, Manila (Philippines) by using wild species *Oryza nivara*, which is high yielding and has solved food problem in Asia by increasing rice production by 5 million tons per year.
- In wheat, efforts of **Dr. N. Borlaug** (Mexican wheat breeder) have led to development of many dwarf wheat varieties like **Sonora-64, Lerma rojo-64** and **Norin-10,** which were introduced in India and increased wheat production.

NEW AND UNDER-UTILIZED CROPS

Out of about 3,50,000 known plants at this time, a few, *i.e.*, about 100 plants are being used for fulfilling man's daily requirements. Scientists are in search of less known and under-utilized crop plants, which can be used for food and other purposes and thus exploitation of traditional plants can be reduced. Such under-utilized and under-exploited plants are known as **new crops.**

Some of these new and under-utilized crops are as follows:

1. Triticale : *Triticale* is the first man made cereal or crop, which has been produced by intergeneric hybridization between **common wheat** (*Triticum aestivum*) and **European rye** (*Secale cereale*) with a view to combine characters of these two parent plants. *Triticale* is **hexaploid,** *i.e.*, $2n = 6x = 42$ (when tetraploid wheat is used) or **octaploid,** *i.e.*, $2n = 8x = 56$ (when hexaploid wheat is used). *Triticale* or *Triticosecale* is not suitable for purpose of bread making due to low gluten content, but it is a good forage crop.

2. Guayule : *Parthenium argentatum* (fam. Asteraceae), commonly known as **carrot grass** or **congress grass.** This is native of **America** and nowadays it is most troublesome terrestrial weed in India and is present in almost all states of India. The roots of this plant secret **transcinnamic acid,** which inhibits the growth of other plants **(allelopathy).** This is a shrub and can grow on poor desert soils. This plant is nowadays used in obtaining rubber, which is called **Guayule rubber,** which is similar to **para rubber** or **hevea rubber.** The body of this plant contains **caotchouc granules,** which are ingredient of rubber. The plant contains **12–20% rubber** on dry wt. basis. This plant can be a natural source of rubber in future.

3. Subabul or Leucaena : *Leucaena leucocephala* (fam. Leguminosae). This is a fast growing small tree and is native of central America. This plant is nowadays being planted on a large scale under **social-forestry.** These plants are used as wind-breaks, fire breaks, cover plant for deforested tropical regions, leaves as fodder, wood as fuel and in charcoal formation, paper pulp, rayon and timber. It is also used as shade and cover plant in coffee, tea and rubber plantations. *Leucaena* is a nitrogen fixing plant and a good green manure plant.

4. Jojoba : *Simmondsia chinensis*: This is a shrub, which is native of Mexican deserts. It is important drought desert plant and hence is being grown in deserts. The seeds of this plant contain about **50% liquid wax,** which is similar to sperm whale oil (spermaceti). This liquid wax was originally used in cosmetics, but now is also being used in high performance lubricants. So, growing of this plant can reduce the pressure on sperm whales, which are killed for their oil. Further growth of this plant in deserts will provide natural cover and thus enhance the economic status of the people living in these arid areas.

5. Winged bean : *Psophocarpus tetragonolobus* (fam. Leguminosae). This is a herbaceous plant, which has capacity of nitrogen fixation. The tuberous roots, leaves, shoots, pods and seeds are highly nutritious due to rich source of proteins. The ripe seeds contain about **34% proteins** and **13% oils** (similar to soybean). Further this plant can be used as a green-manure plant, fodder plant and also as a cover crop.

6. Oil plants : Some potential oil yielding plants are there, which provide edible and non-edible oils after suitable treatments. Some potential oil plants are as follows:

(i) Margosa or Neem : *Azadirachta indica* (fam. Meliaceae).

It is native of Burma (Myanmar) and is widely grown tree in India. Seeds are source of **margosa** or **neem oil** with bitter taste, used in soap making.

(ii) Indrayan or Colocynth : *Citrullus colocynthis* (fam. Cucurbitaceae)

Seeds give oil.

(iii) Mahua : *Madhuca indica*

Seeds give oil, used in soap making and also in cooking purposes.

(iv) Buffalo or Wild gourd : *Cucurbita foetidissima*

Seeds of this arid zone plant provide oil.

(v) Mustard tree or Kharjal : *Salvadora perisca.*

Seeds provide oil, which is used commercially.

(vi) **Sal :** *Shorea robusta*

Trunk yields oleoresin, which is source of 'chua oil' on distillation, which is used in perfumes.

7. **Fodder trees:**
   (i) *Acacia nilotica* (Kikar or Babul)
   (ii) *Albizzia lebbeck* (Siris)
   (iii) *Ficus religiosa* (Peepal)
   (iv) *Morus alba* (White mulberry)
   (v) *Sesbania grandiflora* (Basna)

8. **Some non-alcoholic beverages (Less known):**

(i) *Caltha edulis* : Leaves and buds on chewing have stimulating effect.

(ii) *Cola nitida* : A beverage 'cola' is obtained from seeds in Africa.

(iii) *Ilex paraguariensis* (Mate) : It is source of Paraguay tea.

(iv) *Paullinia cupana* (Yoco) : Used as beverage in S. America.

Social forestry

National Commission on Agriculture (NCA) started this programme in 1976 in India. Social forestry is raising of fast growing and multipurpose species of trees and shrubs by local people on public and common vacant lands and roadsides etc. for fulfilling their **fodder, fuel and small timber** requirements. The species of plants selected for social forestry vary from one locality to another. It reduces the pressure on real forests and also manages soil and water conservation, saves dung for manure and biogas and moderates climatic conditions.

- Important plants recommended for social forestry programme are: *Leucaena, Albizzia, Anogeissus, Ailanthus, Azadirachta, Acacia, Casuarina, Dalbergia, Gmelina, Moringa, Morus, Tectona, Zizyphus*, etc.

BIOENERGY

The energy obtained from biological sources is called bioenergy. Bioenergy is of 2 main types :

(A) **Animal energy**
(B) **Biofuels**

(A) Animal energy

Animal energy is basically of two forms:

(a) Human muscle power (HMP)
(b) Draught animal power (DAP)

(a) **Human muscle power :** It is the form of animal energy, which is used throughout the world in the form of physical work by human race like farmers in the field, women in house work and non agricultural labourers like artisans in wood work, gardeners, etc. A major part of the energy utilized today belongs to this type and it constitutes about 1/5th of the total generated electricity in India.

(b) **Draught animal power :** This power is related to domesticated animals in agriculture and transportation and plays a major role in the rural areas.

(B) Biofuels

Biofuels are the fuels of biological origin. These constitute renewable form of energy. Energy problems can be solved up to a great extent by efficient and proper use of these biofuels. Major sources of biofuels are:

(a) Wood
(b) Agroindustrial waste materials
(c) Agricultural residues
(d) Animal wastes
Waste materials
(e) Energy cropping and petroplants

(a) **Wood :** It is the renewable and most common source of energy in use since time immemorial. Wood which is used as source of energy is called **fuel wood** and about 2 billion people in world are dependent upon wood as source of fuel. Excessive use of wood as fuel has led to deforestation, soil erosion, loss in fertility of soil and hence deterioration of environment.

Characteristics of fire wood:

(i) It should be highly combustible.

(ii) It should have high calorific value and should be free of disagreeable odour.

(iii) The fuel wood plants should be present every where.

(iv) These should be easy to dry and should not split when burnt.

(v) Should be non-resinous in nature and smokeless.

Woods of dicots serve as better fuel wood than gymnospermous woods, because the former provide uniform heat for a long time.

- Some trees providing good **fire-wood** are: *Acacia nilotica, A. senegal, Adina cordifolia* (Haldoo wood), *Albizzia lebbeck* (Siris), *Azadirachta indica* (Neem) *Casuarina, Dalbergia sissoo* (Shisham), *Prosopis, Syzygium cumini* (Jamun), *Mesua ferraea* (Iron wood), *Terminalia tomentosa*, etc.

Where as some **bad fire woods or fuel woods** are: *Mangifera indica* (Mango), *Madhuca indica* (Mahua), *Bombax ceiba* (Semal), *Bauhinia* (Kachnar), *Michelia, Pinus* (Chir), etc.

Due to increase in population, the demand of fuel wood is increasing day by day and this has led to fuel wood crises. In order to overcome fuel wood crisis, following methods have been suggested:

1. To grow more fuelwood trees, *i.e.*, **energy plantations.**
2. Proper designing of wood stoves or chullahs in order to increase efficiency of these and hence to save energy loss.
3. Electric cremation should be enhanced.
4. Energy production from woods by different processes like **carbonisation** (change of wood into carbon/charcoal by heating), **gasification** (change of wood into producer gas by passing steam over incandescent coke), **pyrolysis** (thermochemical conversion of wood into charcoal, pyroligneous acid (10% acetic acid), wood gas, wood tar, wood alcohol, etc.).

(b) Use of waste materials for energy production : Some methods have been devised for bioconversion of agricultural residues, industrial waste materials and animal wastes into energy. This is very important in solving the environmental pollution problems.

Anaerobic fermentation of animal dung leads to production of **biogas** (gobar gas) as well as fertilizer. Biogas consists of 50–70% CH_4 (methane), 30–40% CO_2 ; 1% H_2S and traces of H_2 , N_2 , O_2 and CO.

- Calorific value of biogas is 4,429 kcal/m^3 , when its CH_4 content is 50%.

The **biogas production** involves 3 steps:

(i) The breaking down of polymers into monomers by activity of facultative anaerobes as a result of enzymatic hydrolysis (enzymes are secreted by these microbes).

(ii) Conversion of monomers into organic acids by activity of microbes.

(iii) Conversion of organic acids into CH_4 gas by activity of methanogenic bacteria (anaerobes).

- Important substrates in biogas production are : **Animal wastes** like dung of cattle, urine and slaughter house wastes; **agroindustrial wastes** like oil cakes, sugar industry wastes, wastes from fruits and vegetables processing; agricultural or crop residues; human wastes (night soil); urban solid wastes and also **aquatic plants** like *Eichhornia* (water hyacinth), *Wolffia*, *Hydrilla*, *Salvinia*, *Azolla* and algae, etc.
- In biogas production, water content is maintained at 90% at which most **methanogenic bacteria** are active.

The biogas so produced can be used for different purposes, can be efficiently used and stored easily. Further pathogens of faecal matter can be reduced (sanitation) and thus disease cycles are broken.

(c) Energy cropping and petroplants : These are renewable resources of energy. Growing of crops from which **alcohol** and other energy fuels can be produced, constitute **energy cropping**. Important plants of energy cropping (*i.e.*, **energy crops**) are:

(i) *Saccharum officinarum* (Sugar cane)
(ii) *Beta vulgaris* (Beet root or Chukandar)
(iii) *Solanum tuberosum* (Potato)
(iv) *Zea mays* (Maize)
(v) *Manihot glaziovii* (Tapioca)

These plants are efficient users of solar energy. These plants can be easily changed into **ethanol** (ethyl alcohol). In **Brazil**, ethanol fuel is used in automobiles (95% alcohol), where as in USA, 85–90% petrol is mixed with 10–15% alcohol to form a new fuel called **gasohol**, which is used as fuel in automobiles. But slight modification is required in conventional engines to use these new fuels, *i.e.*, **ethanol** and **gasohol**.

Petroplants or Petrocrops

Latex of some plants containing long chain hydrocarbons is considered to be a good substitute for liquid fuels or petroleum. Such plants having large amount of latex with long chain hydrocarbons are called **petroplants**. Cultivation of petroplants is also a part of energy-cropping. Cultivation of these petrocrops was first of all done by Italians in Ethiopia about fifty years back, although actual credit for identifying the petrocrops goes to **Dr. Calvin**. The most common petroplants belong to families: Euphorbiaceae, Asclepiadaceae, Apocynaceae, Compositae, Labiatae, Sapotaceae, Urticaceae, etc., which have property of converting large amounts of their photosynthates into latex with hydrocarbons. Their hydrocarbon contents can be increased by genetic manipulations (genetic engineering). But commercial production of petroleum or liquid fuel alternative (through petroplants) is in early stage.

- Most common petrocrops are:

(i) *Euphorbia antisyphilitica*
(ii) *E. caudicifolia*
(iii) *E. lathyris* (**Gasoline tree**)
(iv) *E. royleana*
(v) *Calotropis procera*
(vi) *Copaifera langsdorfii* (A Brazilian tree and its sap is a good **alternative for diesel**. About 3 litres of sap per month is produced per tree, which can be filled directly in fuel tank of diesel engine automobile).
(vii) *Cryptostegia grandiflora*
(viii) *Pittosporum resiniferum* (**Petroleum nut**)

The use of these petroplants may reduce the pressure on liquid fuel or petroleum.

BIOTECHNOLOGY

This is recent branch of biology. Biology in relation to technology is called biotechnology or biotechnology is defined as application of living organisms or their processes in manufacturing industries.

Or

Study of use of living organisms and the substances produced due to their activities is called biotechnology.

Mostly micro-organisms are used in many industries as alcohol, enzymes, vaccines, vitamins, antibiotics, organic acids, etc. So, biotechnology is controlled use of microbes for benefit of human beings. In this science, principles of biochemistry, molecular biology and microbiology are mostly used. Some important examples of biotechnology products are:

1. Alcohol : It is the result of yeast fermentation, which is the incomplete oxidation of complex organic compounds with the help of enzymes produced by yeast (Invertase and Zymase)

$$\underset{\text{(Sucrose)}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{Invertase}]{\text{Yeast}} \underset{\text{(Glucose)}}{C_6H_{12}O_6} + \underset{\text{(Fructose)}}{C_6H_{12}O_6}$$

$$C_6H_{12}O_6 \xrightarrow[\text{Zymase}]{\text{Yeast}} \underset{\text{(Ethyl alcohol)}}{2C_2H_5OH} + 2CO_2$$

In the middle of the 19th century, **Louis Pasteur** reported that alcohol, beer and butter milk are the result of yeast fermentation. Yeast fermentation is the basis of **baking** as well as brewing industries, besides preparation of fermented foods like idli, dosa, etc. *Saccharomyces cerevisiae* is commonly called baker's yeast or brewer's yeast, is a saprophytic unicellular ascomycetes fungus growing on sugary solution.

Some other common products of yeast fermentation are:

(i) Beer : It is produced from *Hordeum vulgare* (barley) malt and alcohol content is 4–8%.

(ii) Wine : Produced from grapes by fermentation and alcohol content is 10–20%.

(iii) Brandy : Produced by distillation of wine and alcohol content is 43–57%.

(iv) Gin : Produced from fermented European rye, *i.e., Secale cereale.*

(v) Rum : Produced from molasses of sugar cane and alcohol content is 40%.

Thus the type of the alcohol depends upon medium and agent causing fermentation. The species involved in above case are: *Saccharomyces cerevisiae*, *S. sake*, *S. ellipsoides*, etc.

2. Organic acids : Some organic acids are produced by fermentation caused by fungi and bacteria. Some important are:

(i) Lactic acid : Produced by fermentation of corn starch, molasses, potato, whey, etc., by *Lactobacillus bulgaricus, L. delbrueckii* and *Streptococcus lactis.*

(ii) Acetic acid (Vinegar) : Produced by two step fermentation of sugar cane juice by yeast and *Acetobacter aceti* bacteria.

(iii) Citric acid : Produced by aerobic fermentation of sucrose in beet molasses by *Aspergillus niger* fungus.

(iv) Gluconic acid : Produced during oxidation of glucose by fungi like *Aspergillus, Penicillium, Mucor,* etc.

(v) Fumaric acid : Produced from sugar by activity of *Rhizopus nigricans* (bread mould).

3. Enzymes : The term 'enzyme' was first of all used by **William Kuhne** (meaning—in yeast). Enzymes are the organic substances which enhance the rate of biochemical reactions (without themseleves undergoing any change). Enzymes are also called **biological catalysts or biocatalysts.** Enzymes can also be used outside the cell to catalyse some specific biochemical reactions to manufacture many industrial products. Out of total over 2200 enzymes known today, only a few are used in industries, medicines and food which are as follows:

(i) Proteases or proteolytic enzymes : Obtained from *Aspergillus oryzae* and *Bacillus subtilis* and are used in detergents to remove some proteinaceous stains on clothes.

(ii) Amylases : Obtained from *Bacillus subtilis, Aspergillus niger, A. oryzae,* etc., and are used in beer and bread making. Also used for softening starched clothes.

(iii) TPA (Tissue plasminogen activator) : This enzyme is specifically used in heart patients to dissolve blood clots.

(iv) Papain : This protein digesting enzyme obtained from latex of papaya, is used for making meat tender.

(v) Lactase : Obtained from *Saccharomyces fragilis* and *Torula cremori* and used for making cheese from pasteurized milk and also for preventing lactose crystals in ice-cream.

(vi) Invertase : Obtained from *Saccharomyces cerevisiae* and is used to prevent sandiness in dairy products.

(vii) Thrombin : Obtained from beef plasma and is used for blood clotting in surgical operations.

(viii) Renin (Rennet) : Danish chemist **Christian** Hensen (1874) first obtained it from calf stomach and used for cheese formation.

(ix) Pectinases : Obtained from *Aspergillus lucherisis* and used for destruction of penicillin action.

(x) Cellulase : Obtained from *Myrothecium verrucaria* and used in production of dextrin and fructose.

Enzymes are more fragile than inorganic catalysts. Further these are more expensive and are rapidly deactivated at high temperatures. Stabilization of enzymes is done by **enzyme immobilization,** which is done by fixing it to solid support, entrapping in a gel, cross-linking the enzyme molecules or by encapsulation of enzymes in small artificial cells. This immobilization protects enzyme against attack by proteases. Further immobilized enzymes can be easily separated from reaction mixture at the end of reaction and then can be re-used.

- (For more details of enzymes, see **Deutoplasmic** substances of cell in cell biology)

4. Vitamins : Vitamins are the organic compounds, provided to the body with diet and are required for some biochemical processes in very small amounts. Vitamins were discovered by **C. Funk** (1911) and different types of diseases (like beri-2, scurvy, rickets, night blindness, etc.) are produced as a result of vitamins deficiency. Some microbes are good source of different vitamins and the first microbiologically produced vitamin was **vitamin C** (ascorbic acid) during fermentation with a wild strain of bacteria (by Gyorgy). After this different microbes are being exploited for commercial production of different vitamins. Some important examples of microbes-produced vitamins are:

(i) Riboflavin (Vit. B_2) : It is synthesized for industrial purposes by fermentation with a filamentous yeast, *Ashbya gossypii.* The main sources of Vit. B_2 are cereals, yeast, leafy vegetables, milk, etc. It is precursor of FMN and FAD, which act as coenzymes for dehydrogenases enzymes.

(ii) Cobalamine (Vit. B_{12}) : This vitamin is of animal protein origin like liver, meat, fish. It is not present in vegetarian diet and its deficiency causes **pernicious anemia.** Nowadays this vitamin is being produced by fermentation using *Pseudomonas denitrificans, Bacillus coagulans, B. megatherium* and propionic acid bacteria, *i.e., Propionibacteria.*

(iii) Precursor of Vitamin A, *i.e.,* **carotene** is produced by fermentation using *Blakslea trispora.*

(iv) Precursor of Vitamin C, *i.e.,* L-sorbose by *Glucanobacter oxidans.*

5. Antibiotics : These are the substances of **microbial** origin and having **antimicrobial activity** or these are the chemical substances secreted by one micro-organism, which inhibit or check the growth of other micro-organisms.

First antibiotic discovered was **Penicillin** (wonder drug), from *Penicillium notatum* by **Sir Alexander Fleming** (1928). However, the term 'antibiotic' was given by **Waksman** (1942). Waksman himself discovered two antibiotics *i.e.*, **Actinomycin** (1941) and **Streptomycin** (1942). Main sources of antibiotics are **fungi, bacteria and actinomycetes** and about 7,000 antibiotics are known at this time. There are two main groups of antibiotics:

(A) **Broad spectrum antibiotics** are those which inhibit the growth of many pathogenic species, differing from one another in their structure.

(B) **Narrow spectrum antibiotics** are those which inhibit the growth of a specific pathagenic species.

Different antibiotics have different modes of action, *e.g.*, by destruction of cell membrane, inhibition of cell wall synthesis or checking protein synthesis or inhibition of nucleic acid synthesis.

- Common antibiotics are Penicillin, Streptomycin, Terramycin, Aureomycin, Chloromycetin or Chloramphinicol, Griseofulvin, Neomycin, Erythromycin, Polymyxin, Subtelin, etc.
- Antibiotic of algal origin is **Chlorellin** and of lichen origin is **Usnic acid.**
- (For detailed account of antibiotics of fungal and bacterial origin—See economic importance of fungi and bacteria)

6. Yoghurt : It is a special diet, which is prepared by fermentation of concentrated milk first with *Lactobacillus bulgaricus* and *Streptococcus thermophilus* at 40–46°C for 4 hrs. and then fermentation with yeast.

7. Gibberellins : This plant growth hormone or phytohormone is obtained from a fungus called *Fusarium moniliformae* (or *Giberella fujikuroi*). This was isolated by **Yabuta and Sumuki** (1939). At this time, over 52 gibberellins have been discovered from different plants.

8. Steroids : Steroids are high molecular weight fatty compounds, which are having one 5-carbon ring and three 6-carbon rings. Steroids are of wide distribution in both plants and animals. Cholesterol is one of the most important steroids of animals, which is a precursor of animal hormones (steroid hormones) like **progesterone** and **oestrogen** (female sex hormones) and **testosterone** (male sex hormone).

Steroids are nowadays used as valuable drugs, *e.g.*, in treatment of hormonal disturbances, for suppressing immune response in auto immune diseases, used in formation of birth control pills or contraceptive pills (oestrogens and progesterones).

Rhizopus stolonifer is capable of hydroxylation, necessary for steroid synthesis. (Murray and Peterson, 1950).

Progesterone is precursor of 4 different useful steroids and the micro-organisms used in this conversion are *Rhizopus arrhizus, R. stolonifer* (*R. nigricans*), *Curvularia lunata* (all fungi) and a bacterium *Streptomyces argenteolus*.

9. Insulin : Insulin is a hormone of protein nature (51 amino acids), made of 2 polypeptide chains having 21 and 30 amino acids respectively and joined by disulphide bonds. This hormone is produced by cells of 'Islands of Langerhans' of pancreas and is responsible for controlling blood sugar level. Deficiency of this insulin leads to a disease called *diabetes mellitus*. Insulin supplied from outside can cure this disease.

Banting and Best (1921) first of all isolated insulin from dog's pancreas and used it for curing diabetes patients. Insulin is now obtained from pancreas of slaughtered pigs and cattle. This insulin slightly differs from man's insulin and effectively controls diabetes.

- By using genetic engineering or recombinant DNA technology, insulin producing genes from human beings have been transferred into *E. coli* bacteria, which produce insulin called **'Humuline'** for clinical use. This type of synthetic insulin was produced by an American pharmaceutical firm Eli-Lily on July 5, 1983.

10. Interferons : Interferons (antiviral proteins) were produced by **Charles Weismann** of Zurich University through recombinant DNA technology in *E. coli* in 1980.

11. Monoclonal antibodies : Antibodies are the specialized proteins, which are produced inside the host body in response to foreign substances called antigens (mostly protein or polysaccharides) and provide immunity to the host against antigens. Antibodies are produced in lymph nodes, spleen and liver.

Monoclonal antibodies (Mabs) are the specialized antibodies, which are specific to only one type of antigen. The concept of monoclonal antibodies was put forward by **Georges Kohler** and **Cesal Milstein** in 1974 and these antibodies are produced outside the body by hybrid cell culture technique, known as **Hybridoma technology.** For this technology, **Kohler** and **Milstein** were awarded **Nobel Prize** in 1984.

In this technique, the antigens (against which antibodies are needed) are injected into rat. After some time, the **spleen** of the rat is removed and from spleen, some **lymphocytes** (which are responsible for antibody production) are isolated. These lymphocytes are mixed with **myeloma** cells (tumour cells isolated from cancer of bone marrow). Some of these **lymphocytes** and **myeloma** cells fuse together to form **hybridoma** cells (by somatogamous fusion). These hybridoma cells have capacity of antibody production (of lymphocytes) and rapid cell division (of cancer cells). These hybridoma cells in cultural conditions produce large quantities of specific and pure (monoclonal) antibodies, which are separated and used in cure of different diseases.

12. Vaccines : Production of antibodies against antigens, is the basis of immunity. Vaccine, in fact is dilute dose (suspension) of antigens, which is used for developing artificial or acquired immunity. The process of inoculation of vaccine is known as **vaccination** and **Louis Pasteur** (1850) is responsible for understanding the basis of vaccination and immunization. (**Edward Jenner** 1790, however made earlier studies in relation to smallpox). A vaccine contains either **weakened** (polio, smallpox and measles vaccines) or even **killed** pathogens (typhoid vaccine) which have still antigens to induce antibody production. In some cases (like botulism and tetanus), toxins produced by pathogens serve as vaccines. A large number of vaccines (called first generation vaccines) against different viral and bacterial diseases have been produced.

In recent years, some new vaccines called second **generation vaccines** and **third generation vaccines** have been developed. Second generation vaccines are those, which are produced by recombinant DNA technology or genetic engineering, *e.g.*, vaccine for *Herpes* virus and *Hepatitis* B. Third generation vaccines are produced synthetically or are synthesized vaccines, *e.g.*, for feline leukemia virus and foot and mouth disease virus.

13. **Amino acids :** An important basic amino acid, lysine is produced from diaminopimelic acid (constituent of cell wall of bacteria, *e.g.*, *E. coli*) by activity of bacterium *Enterobacter aerogens*.

14. **Some other food products :** Cheese is produced by activity of different species of *Lactobacillus* and *Streptococcus*.

Penicillium camembertii and *P. roquefortii* are used to give flavour to cheese (camembert cheese and roquefort cheese).

Similarly, **butter** is produced from cream by activity of *Streptococcus lactis* and *Leuconostoc* species.

15. **Dextran :** Sucrose by activity of *Leuconostoc mesenteroides* bacteria, gives rise to a complex polysaccharide called **dextran,** which is used in plasma transfusions.

16. **Tissue culture :** This is also a latest method of crop improvement. Besides also used in manufacture of **antibiotics, alkaloids** and dyes (like **Shikonin,** a red dye used in silk-industry and in treatment of burns is obtained from culture of cells of *Lithospermum* root).(for detailed study, see methods of crop improvement)

BIOPATENT

With emergence of modern biotechnology, one important issue has been raised which is the legal characterization and treatment of trade related biotechnological processes and products, commonly called **intellectual property.** In simple words, intellectual property is a 'product of mind'.

In biotechnology, one of the most important examples of intellectual property is the processes and products, which result from development of genetic engineering techniques through use of restriction enzymes to create recombinant DNA. The rights to protect this property are called **intellectual property rights** (IPR). Intellectual property rights include rights relating to literary, artistic, scientific works, inventions in all fields, industrial designs, trademarks, commercial names, etc. Intellectual property rights include **patents,** Copyright, trade marks and trade secrets.

- A patent is a government granted and secured legal right to prevent other from making, using or selling the inventions covered by patent. A patent is a personal property which can be licensed or sold like any other property.

Under USA law, a patent means grant of right to exclude other from making, using or selling an invention for a 17 years period. **The Indian Patent Act (1970)** allows **process patents** but not product patents. The duration of the patent in India is five years from date of grant of patent or seven years from date of filing the application, whichever is less.

- Patentable subject matter should meet 3 requirements as **utility,** **novelty** and **statutory subject matter.** Different countries have different patent laws and these can be modified from time to time. Complaints of infrigement of these patents are decided by courts in accordance with patent law of that country.
- Patenting of life forms or biological material is called biopatenting and such a patent is called **biopatent.** Before, 1980, life forms could not be patented and the discovery of oil-eating bacterium (genetically engineered *Pseudomonas*) by a non-resident Indian scientist **Dr. Chakrabarty** (called 'Super bug', used for cleaning up oil spills) was first to be patented under standard US patent (*i.e.*, **first biopatent**). Genetically engineered mouse called 'oncomouse' (carrying a human cancer gene) was protected by a US patent in 1988 and this was another milestone in patenting of life forms or biopatents. Issue of biopatenting has also been recently discussed in India.
- In plant biotechnology, live plants, naturally occurring microbes, micropropagation, tissue and organ culture techniques, biological control of pests or hybrid varieties cannot be protected using patents. New crop varieties cannot be patented but **transgenic animals and plants can be patented.**
- The genes and DNA sequences which normally fulfil the requirements of patents have no difficulty in getting patent protection. In 1991, the National Institute of Health (NIH), USA, applied to patent some DNA sequences useful in human gene mapping. This application was opposed on the grounds that it will slow down the flow of scientific information and stop international co-operation and it failed because of cost. A second application on DNA patenting by a private company was turned down on the grounds that the research has been done with public money. But in 1997, the US Patent Office agreed to allow patenting of gene strands with no biological function but likely to have industrial use. The result is that big acadamic labs and companies have been sequencing and patenting sequences in order to secure private investment. In order to distinguish DNA sequences from their natural counterparts (which cannot be patented), a patent application must state that the invention has been purified or isolated or is a part of recombinant molecule or vector. Some pharmaceutical companies and NIH (National Health Institute) are compiling public

databases of sequences ensure public access. Further donor content is a concern in human DNA patenting.

Terminator technology for seed protection : A patent under the title 'control of Plant Gene Expression' was issued on March 3, 1998 jointly to Delta and Pineland (D and PL) and the US Department of Agriculture (USDA). A Canada based NGO, RAFI (Rural Advancement Foundation International) dubbed the technology as 'Terminator technology', as they believed that it will be used to ensure that farmers may not be able to save the seeds from their harvest for replantation. The inventors of this technology have already applied for the patents in atleast 78 countries. **Indian government has banned the entry of any seed material into the country that may carry terminator gene and has decided not be grant patent to D and PL for terminator technology.**

- Patented method for terminator technology is based on a gene that produces a protein that is toxic to plant and thus does not allow the seed to germinate (RIP gene).

Arther Dunkel's Suggestions (1991, 92) : Arther Dunkel, then Director General, GATT (General Agreement of Tariff's and Trade) gave some suggestions for India, which include:

(i) India will have to change the patent laws by 2003 to finally open the agriculture sector for patented biotechnology.

(ii) India will not be able to give any kind of subsidies for production of oil seeds or pulses as the international prices of these commodities are lower than domestic prices.

(iii) India will have to introduce product patents and to increase in duration of patents.

(iv) India will have to open its markets to foreign patent holders.

BIOPIRACY (Biocolonialism)

Biopiracy may be defined as, "The theft of various natural products (of plants and animals) and then selling them by getting patents or intellectual property rights, without giving any benefits (financial or technological) back to the host country or country of origin".

e.g., Biopiracy of Neem, Haldi, Basmati rice, etc.

Biopiracy of Neem : Patenting of seed oil from Indian Neem (*Azadirachta indica* fam. Meliaceae) by US Department of Agriculture (USDA) and W.R. Grace (Columbia) in 1992, was a case of biopiracy (patent No. 436357 BY). For generations, Indians had used Neem oil as a medicine and pest controlling agent. So the US patent on Neem had created a great controversy. In May, 2000 after a long legal battle, the European Patent Office (EPO) revoked the patent of USDA and W.R. Grace.

Biopiracy of Haldi : In March 1995, University of Missisippi Medical Centre (USA) had taken patent on turmeric powder (*Curcuma domestica* fam. Zingiberaceae), as a wound healing agent. But on August 13, 1997, this patent was revoked due to objections of CSIR because for a long time, turmeric powder is used as a wound healing agent in India and it was not a discovery of US patentee.

Similar is the case of biopiracy of Basmati rice.

- Misuse of Intellectual Property Rights (IPR) can lead to Biopiracy, *e.g.*, University of Georgia Scientists explore the Oxaca state of Mexico for indigenous plants of medicinal/pharmaceutical potential and patent any plant with promise. The corporations gain, but people who have used it for ages lose it. This is a major threat to the treasure of traditional knowledge in India/South Asia.
- The problems of ownership and concerns over right of countries were discussed in a document known as Convention on Biological Diversity (CBD) in first Earth Summit, Rio de-Janeiro (1992, Brazil). CBD provides for sovereign rights of individual countries on their genetic resources. USA and EU strongly opposed the view held by developing countries that the sovereign rights of the countries of origin of PGRs (Plant Genetic Resources) held in *ex situ* collections be recognized. These developed countries have been successful in achieving approval for a call to strengthen co-operation to sustain *ex situ* collections and recognizing that states have sovereign rights over their own PGRs (PGRs stored on their territory irrespective of the territory of origin). Thus, recognition of sovereign rights of the countries of origin of PGRs available in gene banks in the developed countries has been rejected by USA and EU. **Therefore, the companies present in Northern countries are dealing directly with agencies where PGRs are located rather than dealing with countries of origin of those PGRs.** A pharmaceutical industry can purchase tropical PGRs from botanical gardens located in temperate countries. According to International Association of Botanical gardens, 50% of world's vascular plants are available in botanical gardens and 75% of these gardens are present in developed countries in the North. The pharmaceutical industry is exploring the possibility of getting rights for chemical analysis of collections at these gardens for development of new drugs, *e.g.*, Pfizer Pharmaceutical Co. (USA) has collaboration with New York Botanical Gardens and through it has connections with Botanical gardens in Hawaii. **This is also a case of Biopiracy through gene banks and botanical gardens.**

BIOTECHNOLOGY AND SUSTAINABLE AGRICULTURE

Green revolution and high impact agriculture have satisfied the food requirements of most of the human population as it has doubled since 1960. But increase in food production has led to serious environmental problems, *i.e.*, high impact agriculture is not sustainable for more than a few decades. So, more and more farmers are trying forms of agriculture that cause less environmental problems. **Sustainable agriculture** (or alternative agriculture or low-input agriculture) is based on beneficial biological processes and environment friendly chemicals. In sustainable agriculture, certain modern agricultural techniques are combined with traditional farming methods. Sustainable agriculture may be simply defined as, "Agricultural methods that rely on beneficial biological processes and environment friendly chemicals rather than conventional agricultural techniques."

In other way, sustainable agriculture may be defined as, "The successful management of resources for agriculture to satisfy human needs while maintaining or enhancing the natural resource base and avoiding environmental degradation."

Hence we can say, sustainable agriculture is not a single programme but there is a series of programmes that are adapted for specific soils, climates and farming requirements. Water and energy conservation, crop rotation, breeding of disease resistant crop plants, use of biofertilizers (BGA fertilizers, mycorrhizae, symbiotic and asymbiotic nitrogen fixers, organic fertilizers, green manures), biological pest control methods and bio-pesticides or Integrated Pest Management (IPM) are practiced in sustainable agriculture.

- (Bio-fertilizers and biological pest control are given separately in detail in this unit).

In addition to these practices, biotechnology also plays a promising role in sustainable agriculture. Biotechnology held the potential of marrying biology and engineering and is essentially an interdisciplinary area consisting of biochemistry, molecular biology, microbiology and genetics. Plant biotechnology includes two major technologies **cell, tissue and organ culture** and the **recombinant DNA technology/genetic engineering**. Cell and tissue culture has many commercial applications which include micropropagation, haploid breeding, productions of secondary metabolites and use in production of transgenic crops or genetically modified crops. Recombinant DNA technology has two major uses namely **molecular marker technology** and **production of genetically modified transgenic crops**. In general genetic engineering promises greater productivity and more nutritious foods.

- The molecular markers have been utilized in characterization, maintenance and sustainable use of PGRs, (plant gentic resources). Their main uses in plant breeding include selection of desirable plants in early segregating generations at the seedling stage and selection of diverse parents for hybridization.
- The most important use of plant biotechnology has been in the production of superior transgenic crops which are having not only resistance to different biotic and abiotic stresses but are also having improved nutritional quality of food.
- Using traditional breeding methods, it takes 15 years or more to introduce disease resistance genes into a particular crop plant but genetic engineering or recombinant DNA technology takes a fraction of that time in achieving the same goal. Further in this method, desirable genes from any organism can be used.
- Genetic engineering may produce more nutritious food plants because they would contain all the essential amino acids. Recently in 2000, an international team of scientists has successfully engineered rice grains to produce beta-carotene or vitamin A (Golden rice or miracle rice). This rice has the potential to improve world health because about half of the world's population use rice as their staple food and rice is a poor source of many vitamins including vitamin A.
- Using genetic engineering, crop plants resistant to insect-pests, viral diseases, drought, heat, cold, herbicides and salty or acidic soils can be developed.
- In a cross of agriculture and medicine, molecular biologists are developing GM plants (genetically modified plants) that give edible vaccines, *e.g.*, antidiarrhea vaccine and cholera vaccine both contained in raw potato. Similarly, extract preventing tooth decay and a vaccine against ulcers have been obtained from GM crops. Bananas (more palatable than potato) are also being genetically modified to provide edible vaccines. Edible vaccines hold important role for developing countries as they can be grown where most needed and they will not require clean needles and constant refrigeration.

Genetically modified crops-transgenic crops have already transformed agriculture and they have been grown in more than 100 million acres of farmer's fields, each in year 1999 and 2000 despite of protests and debates.

- Plant genomics is the latest or new field of plant biotechnology. Under this discipline, complete genome of *Arabidopsis* has been sequenced and of rice is being sequenced. This will lead to find the functions of all genes (reverse genetics), which will be having a great impact in field of cytogenetics, plant breeding and plant pathology. The knowledge from genomics research will be utilized in detection, isolation and manipulation of genes in a variety of crops and thus, novel transgenic crops will be produced. As there is a great complexity of plant system, so let us see which way the wind blows.

Thus plant biotechnology has a great potential to improve agriculture.

BIO-WAR

Pathogenic microbes which are used as weapons, are called **Bioweapons (The unseen enemy)** and the war in which these bioweapons are used is called **Bio-war.**

Mostly bacteria are used as bioweapon as they can be cultured easily on artificial medium in laboratories. Though some viruses, which are kept in some laboratories of a few countries, can also be used. Bioweapons specially anthrax is a burning topic recently because this disease suddenly burst out during war between Northern Alliance and Taliban (Oct. 2001), when public sensitized to the horrors of **bioterrorism.**

But anthrax is not the only weapon in the armoury of bioterrorists, some other pathogens can also be used as bioweapon.

List of some bioweapons

Plague/Black Death : A bacterial disease caused by *Pasteurella pestis/Yersinia pestis*, is believed to have killed millions in the 14th century.

As a bioweapon plague could be disseminated by aerosol. One to six days later, the inhaled bacteria cause pneumonic plague (symptom similar to pneumonia such as fever, cough and bloody sputum). Without treatment pneumonic plague turns lethal resulting in respiratory and kidney failure and shock.

The fact that the disease can spread through droplet infection (coughing and sneezing) make its use as a bioweapon even more deadly.

Smallpox : A viral disease caused by a brick-shaped ds-DNA containing virus–*Variola*. It spreads through droplet infection.

Symptoms : Red rashes first appear in mouth, throat and face. These spread to arms, legs and body. Within a few days rashes turn into the pus filled blisters.

It is highly contagious and there is no treatment for small pox. The smallpox vaccine is highly effective but routine vaccinations were stopped in India in late 70s. In 1979, WHO has announced that smallpox has been eradicated from earth except that which has been kept in four research laboratories of USA, Russia, UK and Japan with the permission of WHO. People are afraid that if terrorists steal or purchase these viruses, they can use them as bioweapon.

Viral haemorrhagic fever : It is caused by a variety of viruses. All of the viruses cause severe illness characterized by fever and internal bleeding. As a weapon these can be spread by aerosols.

Ebolla : It is a viral disease characterized by fever, pain, internal and external bleeding.

Botulism : It is a type of food poisoning caused by *Clostridium botulinum*. It is an obligate anaerobic, endospore forming, Gram positive, rod-shaped bacteria. The canned food which is not sufficiently heated acts as a source of infection. The toxin released by bacteria acts on neuromuscular junction and inhibits exocytosis and release of acetylcholine. This causes failure of muscle contraction leading to paralysis.

Incubation period = 18 to 24 hours.

Control : Giving large doses of botulism antitoxin to patients.

Anthrax (Greek, Anthrax means coal) : It is a bacterial disease caused by Gram positive, rod-shaped, spore forming *Bacillus anthracis*. It mainly occurs in cattle, sheep, horses, etc., and can be transmitted in humans. The bacteria produce endospore which can remain viable for decades. It is not a contagious disease. It is contracted by direct exposure to spores. It is not passed through touch from person to person.

In humans the disease is divided into 3 categories.

(a) **Cutaneous anthrax** (Fatality 20%) : If bacteria enter the body through cut and abrasion of skin. It accounts for 95% of infections.

Symptoms : Rashes appear on skin within 1–2 days of exposure.

(b) **Gastrointestinal anthrax** (Fatality 25–60%) : It is due to the ingestion of contaminated undercooked meat.

Symptoms : Nausea, appetite loss, intestinal cramping, vomiting, fever, diarrhoea, abdominal pain.

(c) **Pulmonary anthrax** (Fatality 80–95%) : It is due to the inhalation of about 2500 spores.

Symptoms : Flu, fever, nausea, accumulation of toxins (exotoxins) released by bacteria lead to difficulty in breathing, toxic shock eventnally death.

Toxins of anthrax bacteria

Exotoxin secreted by bacteria is composed of three proteins. These are collectively called as **Anthrax toxin** and are responsible for the toxicity and lethality.

These three proteins are:

(i) Protective antigen (ii) Lethal factor
(iii) Edema factor

Protective Antigen : It forms a membrane inserting heptamer that facilitates the entry of other two proteins in target cells.

Lethal factor : It disrupts the cell signalling pathway and kills immune system cells.

Edema factor : It binds with calmodulin protein of cell and prevents it from carrying out its signal transduction function. Binding with calmodulin induces a major conformational changes in edema factor's catalytic domain. These changes make the enzyme highly efficient in catalyzing the conversion of ATP into c-AMP. The resulting overproduction of c-AMP causes cell death and fluid accumulation that contribute to Anthrax infection.

Incubation Pd–1 to 7 days.

Prophylaxis—BIOPORT (Pvt. company of USA) is the only manufacturer licensed to produce Anthrax vaccine. But this vaccine is available to Military and laboratory personnels.

Cure : Ciprofloxacin, Penicillin G., Doxycyclin and Erythromycin.

Weaponising Anthrax

- Bacteria (*Bacillus anthracis*) is grown in culture medium in laboratory.
- Endospores of bacteria are purified, separated and concentrated.
- Spores are mixed with dust particles or powder.
- The powder mixture is put into envelops.

MULTIPLE CHOICE QUESTIONS

1. Pesticides kill:
   (a) Bacteria (b) Fungi
   (c) Weeds (d) All of these
2. Use of DDT as pesticide started:
   (a) During world war I (b) During world war II
   (c) In 18th century (d) None of these
3. Which of the following does not belong to organochlorines group of pesticides?
   (a) Aldrin (b) Dialdrin
   (c) Aldicarb (d) Endrin
4. Propoxur belongs to which group of pesticides?
   (a) Organochlorines (b) Organophosphates
   (c) Carbamates (d) Triazines
5. Derivatives of urea, used as herbicides belong to:
   (a) Pyrethoids (b) Triazines
   (c) Carbamates (d) None of these
6. Pesticides are generally:
   (a) Highly selective (b) Selective
   (c) Non-selective (d) None of these
7. A bioherbicide produced from conidia of *Colletotrichum gloeosporioides* is:
   (a) Devine (b) Collego
   (c) Sporeine (d) All of these
8. Control of aphids (homopterous insects) is done by introduction of:
   (a) Praying mantis (lady bug)
   (b) *Bt*
   (c) Nematodes
   (d) None of the above
9. The population of gypsy moth has been controlled by:
   (a) Pheromones (b) Sterilization strategy
   (c) Natural insecticides (d) By predators
10. Integrated pest management (IPM) includes:
    (a) Soil conditioning
    (b) Crop rotation and sanitation
    (c) Starvation
    (d) All of the above
11. Natural insecticides were first of all used by:
    (a) Indians (b) Americans
    (c) Romans and Chinese (d) Russians
12. There is a need of replacement of pesticides by some other methods, because:
    (a) Their long storage is not possible
    (b) These are very costly
    (c) Poisonous and non-biodegradable
    (d) Abnormalities are caused in plants
13. Ideal pesticide is one which:
    (a) Completely controls a pest
    (b) Non-poisonous and biodegradable
    (c) Non-persistent
    (d) All of the above
14. The first pesticide to be used commercially was:
    (a) DDT (b) 2, 4-D
    (c) Burgandy mixture (d) Bordeaux mixture
15. The first bioherbicide developed in 1981 was based on:
    (a) *Phytophthora palmivora* (b) *Phytophthora infestans*
    (c) *Bacillus thuringiensis* (d) *Azadirachta indica*
16. DDT is a:
    (a) Triazine (b) Carbamate
    (c) Organochlorine (d) Organophosphate
17. Body fat of Indian people contains:
    (a) 1 to 12 ppm of DDT (b) 11 to 30 ppm of DDT
    (c) 31 to 50 ppm of DDT (d) No DDT at all
18. Herbicide interferes with:
    (a) Carbon dioxide absorption
    (b) Water absorption
    (c) Translocation of sugar
    (d) Photolysis of water
19. First bioherbicide was:
    (a) Phycoherbicide (b) Mycoherbicide
    (c) Nematoherbicide (d) Bacterioherbicide
20. Which of the following is not correctly matched?
    (a) Pyrethoid–Atrazine
    (b) Organochlorine–DDT
    (c) Organophosphate–Malathion
    (d) Carbamate–Carbaryl
21. Nerve gas causes:
    (a) Inhibition of respiration
    (b) Inhibition of photosystem
    (c) Inhibition of acetylcholine esterase
    (d) None of the above
22. Which pesticides are lipophilic?
    (a) Triazines (b) Pyrethoids
    (c) Organophosphates (d) Organochlorines
23. The chemical present in Baygon is:
    (a) Aldicarb (b) Propoxur
    (c) Carbofuran (d) Malathion
24. Which is a fungicide? **(BHU 1995)**
    (a) 2, 4-D (b) DDT
    (c) Bordeaux mixture (d) BHC
25. Mode of action of following pesticides is similar:
    (a) Organochlorines and Carbamates
    (b) Organophosphates and Carbamates
    (c) Organochlorines and Organophosphates
    (d) DDT and parathion
26. Pheromones are chemicals that are used in animals for:
    (a) Sex attractants (b) Sending alarm signals
    (c) Marking trails (d) All of these

*27. Rotenone is a: **(CBSE 1995)**
    (a) Hormone (b) Chemical pesticide
    (c) Natural insecticide (d) Bioherbicide

28. One of the earliest pesticide employed by human beings was: **(MPPMT 1990)**
(a) DDT (b) Nicotine
(c) Neem leaves (d) Pyrethrum

29. The compound extracted from Neem which keeps away the insects is:
(a) Phenyl carbamate (b) Aldicarb
(c) Pyrethoids (d) Azadirachtin

30. Pyrethrin is obtained from:
(a) *Azadirachta indica*
(b) *Helianthus annuus*
(c) *Chrysanthemum cinerarifolium*
(d) None of the above

31. Insecticides kill:
(a) Only specific insects
(b) Only plant pests
(c) Harmful insects
(d) Both harmful and useful insects

32. Major drawback of DDT as a pesticide is that : **(CBSE 1994)**
(a) Organisms at once develop resistance to it
(b) It is significantly less effective than other pesticides
(c) Its cost of production is high
(d) It is not easily and rapidly degraded in nature

33. Which of the following alkaloids are good plant insecticides?
(a) Nicotine (b) Cinerine
(c) Pyrethrum (d) All of these

34. Transgenic crop developed to tolerate herbicides is:
(a) Sunflower (b) Tomato
(c) Tobacco (d) Both (b) and (c)

35. A natural insecticide obtained from plants is: **(AMU 1990)**
(a) Azadirachtin
(b) Rotenone
(c) Nicotine, Pyrethrum and Cinerin
(d) All of the above

36. What is DDT? **(BHU 1990)**
(a) Organochlorine (b) Organophosphate
(c) Carbamate (d) Triazine

*37. VAM is:
(a) Bioinsecticide (b) Bioherbicide
(c) Endomycorrhiza (d) Ectomycorrhiza

38. Household pesticides are:
(a) DDT
(b) Finit (flit)
(c) Finit and baygon
(d) Finit, baygon, mosquito repellent coils and cakes

39. The pesticides most toxic to vertebrates are:
(a) Carbamates (b) Organochlorines
(c) Organophosphates (d) None of these

40. Biological control of agricultural pests, unlike chemical controls is: **(CBSE 1994)**
(a) Very expensive (b) Toxic
(c) Self perpetuating (d) Polluting

41. The pesticides having very low biodegradation and strong affinity for fatty tissues are:
(a) Triazines (b) Organochlorines
(c) Pyrethoids (d) Organophosphates

42. Uprooting of weeds is a method of controlling them: **(AFMC 1990)**
(a) Mechanically (b) Culturally
(c) Chemically (d) Biologically

43. Pests resistant to insecticides have:
(a) Capacity of faster storage of toxin in fat
(b) Enzymes for metabolising toxins
(c) Less permeable utricles
(d) All of the above features

44. In India, the most commonly used pesticide is:
(a) DDT (b) BHC
(c) Aldrin (d) Endrin

45. Full form of BHC is:
(a) Benzene hydrochloride (b) Benzene homochloride
(c) Benzene hexachloride (d) Benzene heptachloride

46. A major pest eradicated through release of male sterile is:
(a) Screw worm (b) Aphids
(c) Ladybug (d) Praying mantis

47. Carbamates used as herbicides are:
(a) Dithiocarbamates
(b) Phenyl carbamates
(c) Thiocarbamates
(d) Phenyl carbamates and thiocarbamates

48. Cochineal insect has been used in checking the mild growth of:
(a) *Opuntia* (b) *Eichhornia*
(c) Aphids (d) Screw worm

*49. Biopesticides have been recommended:
(a) Because of their cheap rates
(b) Because of their abundance
(c) To prevent ecodegradation
(d) Because of their ready availability

50. Which insect was used to check the spread of cacti?
(a) *Coleus eurythaeum* (b) *Cactoblastis cactorum*
(c) *Neotipreon certifer* (d) None of these

51. In which country sporeine was developed?
(a) USA (b) Italy
(c) Germany (d) France

52. Which of the following ingredient of pesticide killed hundreds of people in Bhopal gas tragedy? **(DPMT 1990)**
(a) Carbon tetrachloride (b) Methyl isocyanate
(c) Mustard gas (d) Nitrous acid

53. Pesticides include:
(a) Insecticides only
(b) Herbicides and insecticides
(c) Insecticides, nematicides and rodenticides
(d) Insecticides, fungicides, nematicides, rodenticides and herbicides

54. A transgenic crop that is resistant to hornworm larvae is:
(a) Sunflower (b) Tomato
(c) Tobacco (d) Sugar cane

55. The common mode of action of most insecticides is through the attack on:
(a) Nervous system (b) Circulatory system
(c) Respiratory system (d) Muscular system

56. First bioinsecticide to be developed on commercial scale was:
(a) Sporeine (b) Morphine
(c) Quinine (d) None of these

57. Most effective pesticide is: (MDAT Bihar 1992)
(a) Carbamates (b) Organochlorines
(c) Organophosphates (d) All of these

58. Zinc phosphide is a pesticide used for:
(a) Spraying (b) Fumigation
(c) Killing weevils (d) Killing rodents

59. 2, 4-D is an effective: (CBSE 1996)
(a) Wormicide (b) Rodenticide
(c) Fungicide (d) Weedicide

60. Herbicide prevents: (MPPMT 1994)
(a) Transpiration (b) Water absorption
(c) Translocation of solutes (d) Photolysis of water

61. Which is the most famous pesticide of the world?
(a) Flit (b) DDT
(c) BHC (d) Baygon

62. Which pesticide is used in foundation of buildings to check termites?
(a) BHC (b) DDT
(c) Aldrin (d) Baygon

63. Which of the following is ingredient of odomos and good night mats?
(a) Baygon (b) Allethrin
(c) Aldrin (d) DDT

64. The loss of agricultural productivity by pests is:
(a) 3% (b) 30%
(c) 50% (d) 90%

65. Sporeine is a bioinsecticide based on:
(a) *Phytophthora* (b) *Colletotrichum*
(c) *Bacillus thuringiensis* (d) All of these

66. Pyrethrin is an ingredient of:
(a) Mosquito mats (b) Mosquito coils
(c) Fly sprays (d) All of these

67. Common name of BHC is:
(a) Baygon (b) Propoxur
(c) Gammexane (d) Endosulphon

68. An earliest natural bioinsecticide of Chinese origin is:
(a) Rotenone from *Derris* roots
(b) Azadirachtin from *Margosa* leaves
(c) Pyrethrin from *Chrysanthemum*
(d) None of the above

*69. The concentration of pesticide required to destroy 50% of the pest is called: (MPPMT 1993)
(a) LC 50 (b) LE 50
(c) LD 50 (d) LB 50

70. Which is being used for wide scale antimalaria drive?
(a) Propoxur (b) DDT
(c) Malathion (d) Carbofuran

71. Bordeaux mixture was discovered by: (BHU 1997)
(a) Bordeaux (b) Millardet
(c) Harrison (d) Khorana

72. Antifeedant compound present in Neem is:
(a) Nicotine (b) Cinerin
(c) Pyrethrum (d) Azadirachtin

73. A protein toxin produced by *Bacillus thuringiensis* is:
(a) Thurioside (b) Cinerin
(c) Bactrin (d) None of these

*74. Insect hormone which is used as bioinsecticide is:
(a) Pheromone (b) Hybridome
(c) Renin (d) None of these

*75. Cylinder acting as death trap, having pheromones, have:
(a) Male pheromones (b) Female pheromones
(c) Sterile males (d) All of these

76. When a natural predator living being is applied on the other pathogen organism to control them, this process is called: (CBSE 1996)
(a) Biological control (b) Genetic engineering
(c) Artificial control (d) Confusion technique

77. Cochineal insects have proved very useful for: (CBSE 1996)
(a) Weed control (b) *Parthenium* control
(c) Cactus-prevention (d) *Eichhornia* prevention

78. A technique used for biological control of red-weavil (a pest on coconut), which has been developed by Central Plantation Research Institute, is:
(a) Use of bacteria (b) Male sterility technique
(c) Use of sex attractants (d) Use of predators

79. Besides water, chemical constituents of Bordeaux mixture are:
(a) Copper sulphate and Calcium hydroxide
(b) Copper hydroxide and Calcium sulphate
(c) Sodium sulphate and Copper hydroxide
(d) None of the above

80. Two substances, *i.e.*, devine and collego-are:
(a) Biofertilizers
(b) Bioinsecticides
(c) Hormones of insects origin
(d) Bioherbicides

81. Sugar cane scale insects can be biologically controlled by:
(a) Use of parasites (b) Use of predators
(c) Use of sex attractants (d) Sterile male technique

82. Control of mosquito larvae can be done by:
(a) Cochineal insect (b) Gambusia fish
(c) Lady bird beetles (d) None of these

83. Modern pest control method is:
(a) Pesticides application
(b) Biological control
(c) Use of fertilizers
(d) Integrated pest management

84. Which of the following group of pesticides are organophosphates?
(a) Aldrin, dialdrin, DDT
(b) Malathion, parathion and fenitrothion

(c) Carbaryl, carbofuran, aldicarb, propoxur
(d) Pyrethrin and its derivatives

85. In the silkworm if no juvenile hormone is present when it moults it will: **(CBSE 1997)**
(a) Die (b) Moult into an adult
(c) Moult into larval stage (d) Moult into pupa

86. Partially decayed organic matter added to the soil for increasing soil fertility, is called:
(a) Manure (b) Fertilizer
(c) Biofertilizer (d) None of these

*87. Symbiotic bacterium *Rhizobium* fixes atmospheric N_2 in presence of a pigment, called:
(a) Haemoglobin (b) Leghaemoglobin
(c) Cytochrome (d) Chlorophyll

88. A loose association of *Azospirillum* bacteria with roots of some grasses was first reported by:
(a) Khorana (b) Pasteur
(c) Dobreiner (d) Schneider

89. Many fold increase in food productivity is due to:
(a) Pest control
(b) Crop improvement
(c) Application of fertilizers
(d) All of the above

90. Role of biofertilizers is in:
(a) Nitrogen addition to soil
(b) Organic matter enrichment
(c) Soil texture modification
(d) Enrichment of soil in nutrients

91. Which of the following is not a biofertilizer?
(a) *Azolla-Anabaena* symbiosis
(b) Mycorrhiza
(c) Legume-*Rhizobium* symbiosis
(d) Algae-fungi symbiosis

92. Yield of wheat, rice, maize, etc., can be increased by inoculating a free living nitrogen-fixing bacteria called:
(a) *Azotobacter* (b) *Rhizobium*
(c) *Mycobacterium* (d) None of these

93. Green manure can be prepared by:
(a) Addition of urea to green plants
(b) Storage of green leaves in a water tank for few days
(c) Ploughing down of green crop in field
(d) None of the above

*94. Green manure crops are:
(a) Mostly leguminous (b) Mostly cereals
(c) Both (a) and (b) (d) None of these

95. The reason behind the replacement of chemical fertilizers by biofertilizers is that:
(a) Former are costly
(b) Former cause pollution
(c) Former require huge energy for their manufacture
(d) All of the above

96. Fertilizers applied to crop plants, pollute:
(a) Water resources
(b) Soil resources
(c) Both water and soil resources
(d) Soil, water and atmosphere

97. The chemical fertilizer required for better rhizobial nitrogen fixation is:
(a) Potassium (b) Sodium
(c) Calcium (d) Phosphorus

98. Green manuring increases the crop yield by:
(a) 5–10% (b) 15–25%
(c) 30–50% (d) 80–90%

*99. BGA is chiefly used as biofertilizer in the crop of: **(MPPMT 1995)**
(a) Wheat (b) Gram
(c) Paddy (d) Mustard

100. Nitrogen fixation by *Rhizobium* is increased in the presence of:
(a) Nitrogen (b) Phosphorus
(c) Potassium (d) All of these

101. Which of the following is most commonly used for green manuring in India?
(a) Sun hemp (b) Lentil
(c) Cow pea (d) All of these

102. Vesicular-arbuscular mycorrhizae are important in :
(a) Nitrate nutrition of plants
(b) Phosphate nutrition of plants
(c) Carbonate nutrition of plants
(d) Sulphate nutrition of plants

*103. The percentage of nitrogen content in urea is:
(a) 26% (b) 36%
(c) 46% (d) 56%

104. The leaves of *Azolla* house the colonies of:
(a) *Rhizobium* (b) *Azotobacter*
(c) *Anabaena* (d) *Azospirillum*

105. Composited manure is formed from:
(a) Farm refuse and household refuse
(b) Rotted vegetables and animal refuse
(c) Organic wastes from which biogas is extracted
(d) Farmyard manure and green manure

106. Which of the following statements is incorrect?
(a) Chemical fertilizers are costly
(b) Fertilizers cause pollution of soil and water resources
(c) Biofertilizers improve soil fertility
(d) Chemical fertilizers do not cause land degradation

107. The best biofertilizer for rice is:
(a) *Rhizobium meliloti* (b) *Azolla pinnata*
(c) *Bacillus polymyxa* (d) *Bacillus megatherium*

108. Which of the following is the important requirement for crop plant?
(a) Nitrogen (b) Iron
(c) Zinc (d) None of these

109. A manure supplies to the plant:
(a) Nitrogen (b) Phosphorus
(c) Potassium (d) All nutrients

110. Basic slag is:
(a) Water soluble phosphatic fertilizer
(b) Citric acid and soluble phosphatic fertilizer
(c) Insoluble phosphatic fertilizer
(d) None of the above

111. Total consumption of fertilizers in our country is about: (EAMCET 1990)
(a) 5·2 M tons (b) 9·2 M tons
(c) 11·21 M tons (d) 14·2 M tons

112. The nitrogen fixing bacteria associated with maize roots belong to the genus: (DPMT 1990)
(a) *Azotobacter* (b) *Aulosira*
(c) *Azospirillum* (d) *Azorhiza*

113. Biofertilizers are:
(a) Fertilizers obtained by decay of dead organisms
(b) Fertilizers prepared by mixing cattle dung with crop wastes
(c) Fertilizers formed by ploughing in barseem
(d) Some bacteria

114. Straight fertilizers contain: (CBSE 1990)
(a) One primary nutrient (b) Two primary nutrients
(c) Three primary nutrients (d) Many primary nutrients

115. The most quickly available source of nitrogen to plants are:
(a) Nitrate fertilizers
(b) Ammonical fertilizer
(c) Ammonical-nitrate fertilizer
(d) Amide fertilizer

116. Rhizosphere is the region where: (CPMT 1992)
(a) *Rhizobium* forms root nodules
(b) Algae and root make contact
(c) Soil and root make contact
(d) Bacteria and root nearly make contact

117. Root nodules for nitrogen fixation of a non-leguminous tree (*Casuarina*) possess: (BHU 1994)
(a) *Frankia* (b) *Rhizobium*
(c) *Thiobacillus* (d) *Azotobacter*

118. VAM represents: (Har. PMT 1994)
(a) Saprophytic fungi (b) Symbiotic fungi
(c) Saprophytic bacteria (d) Symbiotic bacteria

119. Which statement is correct? (CBSE 1994)
(a) Legumes fix nitrogen through bacteria in their leaves
(b) Legumes fix nitrogen through bacteria in their roots
(c) Legumes fix nitrogen independent of bacteria
(d) Legumes do not fix nitrogen

120. Mycorrhiza represents: (CBSE 1994)
(a) Antagonism (b) Endemism
(c) Parasitism (d) Symbiosis

121. Which element plays an important role in nitrogen-fixation?
(a) Mn (b) Mo
(c) Cu (d) Zn

122. Crop rotation is carried out for: (AFMC 1996)
(a) Increasing acidity of soil
(b) Decreasing fertility of soil
(c) Increasing fertility of soil
(d) All of the above

123. Leghaemoglobin occurs in: (MDAT Bihar 1996)
(a) Coralloid root (b) BGA
(c) Mycorrhiza (d) Around bacteriods

124. Nitrogen fixation is: (CPMT 1996; APMEE 1996)
(a) Nitrogen → Ammonia
(b) Nitrogen → Amino acids
(c) Nitrogen → Nitrates
(d) Both (a) and (c)

125. *Azotobacter* and *Bacillus polymyxa* are: (CBSE 1996)
(a) Decomposers
(b) Non-symbiotic nitrogen fixer
(c) Symbiotic nitrogen fixer
(d) Pathogenic bacteria

126. *Azolla* as biofertilizer, increases the yield of rice fields by:
(a) 10% (b) 20%
(c) 30% (d) 50%.

127. A biofertilizer provides to crop plant:
(a) All nutrients (b) A few nutrients
(c) Humus (d) None of these

128. In VAM, there is formation of:
(a) Intracellular cortical vesicles
(b) Intracellular branched cortical arbuscules
(c) Both (a) and (b)
(d) None of the above

129. Mycorrhiza enhance:
(a) Uptake of water (b) Uptake of nutrients
(c) Both (a) and (b) (d) None of these

130. Endomycorrhiza is produced by:
(a) Septate fungi
(b) Non-septate fungi
(c) Both septate and non-septate fungi
(d) None of the above

131. Nitrogen fixing cyanobacteria derive their energy through:
(a) Respiration (b) Photosynthesis
(c) Both (a) and (b) (d) None of these

132. Organisms associated with sorghum and cotton, which provide nutrition to them are:
(a) *Azospirillum, Azotobacter*
(b) *Azotobacter, Azospirillum*
(c) *Rhizobium, Azotobacter*
(d) *Anabaena, Rhizobium*

133. The material of biological origin, which is used to maintain and improve soil fertility is:
(a) Biopesticides (b) Fertilizers
(c) Green manure (d) Bionutrient

134. The main sources of biofertilizers are:
(a) Bacteria (b) Fungi
(c) Cyanobacteria (d) All of these

135. Biofertilizers are: (CBSE 1997)
(a) Cow dung manure and farmyard waste
(b) A quick growing crop ploughed under
(c) *Anabaena* and *Azolla*
(d) None of the above

136. Which is not a characteristic of ectomycorrhiza?
(a) It increases interface area between roots and soil
(b) It is mycelium on outer surface of roots
(c) It absorbs and stores nitrogen, phosphorus, potassium and calcium in fungal mantle
(d) It is present in orchids

137. Which is a phosphate fertilizer?
(a) Urea (b) Ammonium nitrate
(c) Bone meal (d) None of these

138. A leguminous plant living in symbiotic association with *Rhizobium* and *Aerorhizobium, i.e.,* two nitrogen fixing bacteria, is:
(a) *Crotolaria juncea* (b) *Sesbania aculeata*
(c) *Sesbania rostrata* (d) *Cyamopsis tetragonoloba*

139. Most active nitrogen fixing member of cyanobacteria in rice fields is:
(a) *Nostoc* (b) *Aulosira*
(c) *Anabaena* (d) *Tolypothrix*

140. A legume *Sesbania rostrata* is having:
(a) Root nodules (b) Leaf nodules
(c) Stem nodules (d) Both (a) and (c)

141. Green manures provide:
(a) Inorganic substances
(b) Organic substances
(c) Check soil erosion and leaching of minerals
(d) All of the above

142. Which of the following is not a green manure crop?
(a) *Cyamopsis* (b) *Melilotus*
(c) *Macrotyloma* (d) *Sorghum*

143. Which of the following is a biofertilizer living in roots of leguminous plants?
(a) *Anabaena* (b) *Azospirillum*
(c) *Rhizobium* (d) All of these

144. Which of the following is not a cyanobacteria?
(a) *Azolla* (b) *Anabaena*
(c) *Tolypothrix* (d) *Aulosira*

145. Which of the following bacteria fix atmospheric N_2 in soil, irrespective of specific crop association?
(a) *Azotobacter* (b) *Bacillus polymyxa*
(c) *Beijerinckia* (d) All of these

146. The method of raising plants from seeds is called:
(a) Domestication (b) Cultivation
(c) Emasculation (d) None of these

147. Which of the following is a method of crop improvement?
(a) Selection
(b) Hybridization
(c) Tissue culture and genetic engineering
(d) All of the above

148. Progeny of single self-fertilized homozygous plant is:
(a) Clone (b) Pure line
(c) Inbred (d) None of these

149. Pure line selection is used as a method of crop improvement in:
(a) Self pollinated plants
(b) Cross pollinated plants
(c) Vegetatively propagated plants
(d) All of the above

150. Method particularly important for improvement of cross pollinated plants is:
(a) Pure line selection (b) Mass selection
(c) Clonal selection (d) None of these

151. Emasculation is step of:
(a) Selection (b) Mutation breeding
(c) Hybridization (d) Introduction

152. Emasculation is: **(MPPMT 2001)**
(a) Removal of male reproductive part of a flower
(b) Removal of female reproductive part of a flower
(c) Method of artificial culture
(d) None of the above

153. Superiority of hybrid over its parents is called:
(a) Heterosis (b) Necrosis
(c) Chlorosis (d) Epistasis

154. Disease free plants can be produced by:
(a) Asexual reproduction (b) Sexual reproduction
(c) Meristem culture (d) Embryo culture

***155.** Embryoids are:
(a) Highly active embryos
(b) Embryos produced from reproductive cells
(c) Embryos produced from somatic cells in tissue culture
(d) Dead embryos

156. Micropropagation is:
(a) Propagation of bacterial cells or microbes
(b) Multiplication through tissue culture
(c) Multiplication under microscope
(d) None of the above

157. Protoplast separation for protoplast culture is done by:
(a) Dissolving cell wall with cellulase enzyme
(b) Dissolving cell wall with pectinase enzyme
(c) Dissolving cell wall with cellulase and pectinase enzymes
(d) None of the above

***158.** Protoplast fusion is brought about by:
(a) Cellulose (b) Agar-2
(c) Polyethylene glycol (d) All of these

159. Tissue culture technique is based on concept of:
(a) Regeneration (b) Totipotency
(c) Cytokinesis (d) None of these

***160.** Latest method of crop improvement is:
(a) Selection (b) Mutation
(c) Genetic engineering (d) Tissue culture

161. Which is called 'genetic scalpel'?
(a) PEG (b) Pectinase
(c) Restriction enzyme (d) Cellulase

162. Which of the following method is not used for crop improvement?
(a) Introduction (b) Inbreeding
(c) Hybridization (d) Tissue culture

163. Polyploidy is induced by: **(BHU 1992)**
(a) Kinetin (b) GA_3
(c) Colchicine (d) IAA

***164.** Hexaploid wheat is:
(a) *Triticum monococcum* (b) *T. durum*
(c) *T. turgidum* (d) *T. aestivum*

165. Inbreeding is possible between two members of: (AFMC 1991)
(a) Order (b) Family
(c) Genus (d) Species

166. Famous and improved IR-8 variety of rice is introduction in India from:
(a) Japan (b) Peru
(c) Taiwan (d) Philippines

167. Improved wheat variety having gene for dwarfness and higher percentage of protein is:
(a) Kalyan (b) Sharbati sonara
(c) Sonalika (d) Lerma rojo

168. Best method to increase crop yield is:
(a) By weed eradication
(b) By use of tractors
(c) By sowing seeds of improved varieties
(d) None of the above

169. Hereditary variation can be induced by:
(a) Auxin (b) GA
(c) Aldrin (d) X-rays

170. Heterosis is: (MPPMT 1995)
(a) Hybrid sterility (b) Hybrid vigour
(c) Hybrid breakdown (d) Hybrid incompatibility

171. Hybrid of potato and tomato is: (DPMT 1996)
(a) Tomato (b) Pomato
(c) Potamoto (d) None of these

172. Androgenic haploids are used for: (DPMT 1996)
(a) Raising stock for micropropagation
(b) Induction of mutations
(c) Knowing effect of all genes
(d) Preparation of homozygous diploids

173. Most of the early civilizations were based on:
(a) Rice
(b) Wheat
(c) Maize
(d) Wheat, rice, maize and barley

174. Common bread wheat is:
(a) Diploid (b) Tetraploid
(c) Hexaploid (d) Octaploid

175. 'Remei' variety, which is the result of mutation, belongs to:
(a) Wheat (b) Rice
(c) Barley (d) Maize

176. First artificial hybrid between carnation and sweet william was produced by: (EAMCET 2002)
(a) Kolreuter (b) Fairchild
(c) G.H. Shull (d) Camerarius

177. Term heterosis was given by:
(a) Shull (b) Kolreuter
(c) Fairchild (d) None of these

178. Desired improved varieties of economically useful crops are raised by: (MPPMT 1994; BHU 1997)
(a) Natural selection (b) Hybridization
(c) Mutation (d) Biofertilizer

179. Reproducing new plants by cells instead of seeds is known as: (MPPMT 1994; BHU 1997)
(a) Biofertilizer (b) Tissue culture
(c) Mutation (d) Antibiotics

180. Adjustment of an introduced plant in changed or new locality is called:
(a) Selection (b) Acclimatization
(c) Tolerance (d) Introduction

181. Maximum of our crops are:
(a) Autopolyploids (b) Allopolyploids
(c) Auto-allopolyploids (d) None of these

*182. Axenic culture means: (AFMC 2000)
(a) Culture lacking agar-agar
(b) Culture of cell
(c) Culture without contamination
(d) Culture of pollen

183. The first domesticated wheat was:
(a) *Triticum monococcum* (b) *T. durum*
(c) *T. aegilopoids* (d) *T. spelta*

*184. Seedless varieties of watermelon are:
(a) Diploid (b) Triploid
(c) Tetraploid (d) Monoploid

185. Common method of micropropagation is:
(a) Multiple shootlet production
(b) Somatic embryogenesis
(c) Both (a) and (b)
(d) None of the above

*186. The name 'explant' is given to:
(a) Plant produced by tissue culture
(b) Plant produced by recombinant DNA technology
(c) A cell or cells used for culture in tissue culture technique
(d) None of the above

187. Increase in yield as a result of heterosis or hybrid vigour is:
(a) 10–15% (b) 50–100%
(c) 25–50% (d) 25–300%

188. Centre of origin of mango and banana, according to Vavilov is:
(a) South-West Asia (b) South-East Asia
(c) Ethiopia (d) China

189. A widely cultivated new world crop of Kerala is:
(a) *Musa paradisiaca* (b) *Hevea brasiliensis*
(c) *Manihot esculenta* (d) None of these

190. Famous variety Sharbati Sonora of wheat has been produced from Mexican dwarf wheat variety Sonora-64 by:
(a) X-rays irradiation (b) Gamma-rays irradiation
(c) Hybridization (d) UV-rays irradiation

191. Rice variety developed by mutation breeding is:
(a) Atomita-2 (b) Remei
(c) Jagannath (d) All of these

192. Tissue culture technique requires:
(a) Complete sterilization (b) pH 5.0 to 6.0
(c) 18 to 25°C temperature (d) All of these

193. Which is the application of tissue culture?
(a) Micropropagation
(b) Rare hybrid production and somatic hybridization
(c) Disease free and haploid plants production
(d) All of the above

194. First successful pollen culture was done by:
(a) Guha and Maheshwari
(b) Swaminathan
(c) B.P. Pal
(d) H.Y. Mohan Ram

195. Uncontrolled plant introduction in India has resulted in introduction of disease:
(a) Flag smut of wheat (b) Late blight of potato
(c) Leaf rust of coffee (d) All of these

196. Which of the following fruits in India is the result of plant introduction and acclimatization?
(a) Guava and loquat (b) Grapes and papaya
(c) Litchi and chiku (d) All of these

197. Green revolution means:
(a) Increase in production of food plants
(b) Increase in growth of green plants for maintaining ecosystem balance
(c) Growth of green plants in order to check soil erosion
(d) None of the above

198. Process of cultivation of wild species of plants in order to fulfil human needs is called:
(a) Cultivation (b) Introduction
(c) Farming (d) Domestication

199. A multipurpose plant preferred for early cultivation by man was:
(a) Maize (b) Coconut
(c) Barley (d) Mango

200. The process of bringing together of different characters into one plant and multiplying it, is called:
(a) Hybridization (b) Micropropagation
(c) Cultivation (d) Crop improvement

201. Branch dealing with production of superior varieties is called:
(a) Genetic engineering (b) Tissue culture
(c) Plant breeding (d) Crop improvement

202. Crossing of two or more plants of unlike genetic constitution is called:
(a) Selection (b) Hybridization
(c) Mutation (d) Somaclonal variation

203. Pioneer worker in plants tissue culture is:
(a) Guha and Maheshwari (b) Steward
(c) Haberlandt (d) Swaminathan

204. Induced mutations can be maintained through:
(a) Sexual reproduction (b) Vegetative propagation
(c) Hybridization (d) None of these

205. Androgenic haploids are:
(a) Haploids produced by pollen culture
(b) Haploids produced by shoot meristem culture
(c) Haploids produced by protoplast culture
(d) None of the above

206. Complete sterilization of glass wares, etc., in tissue culture is done by:
(a) Autoclaving (b) Alcohol treatment
(c) UV-rays (d) None of these

207. Variation of plants produced by tissue culture are known as:
(a) Androgenic variations (b) Induced variations
(c) Somaclonal variations (d) None of these

208. First step of tissue culture is:
(a) Organogenesis (b) Callussing
(c) Somaclonal variations (d) None of these

209. Triploids are present in:
(a) Watermelon (b) Banana
(c) Apple and pear (d) All of these

210. Limitation of mutation breeding is:
(a) Lethality
(b) Undesirable mutations
(c) Recessive nature of mutations
(d) All of the above

211. Earlier agriculture was cultivation of plants by:
(a) Vegetative parts (b) Seeds
(c) Pollens (d) Eggs

212. Concept of 'centre of origin' was first of all given by:
(a) Darwin (b) De Candolle
(c) Vavilov (d) None of these

*213. Centre of origin or natural home of a cultivated crop is that where:
(a) Maximum number of varieties grow in wild state
(b) Maximum number of varieties grow in cultivated state
(c) Maximum number of varieties grow in wild and cultivated state
(d) None of the above

214. Centre of origin of maize is:
(a) Peru (b) Tropical America
(c) Brazil (d) Ethiopia

215. Genetic diversity is shown by plants due to:
(a) Intraspecific breeding
(b) Interspecific breeding
(c) Both intra and interspecific breeding
(d) None of the above

216. Sum total of all genes in a population or a species is called:
(a) Gene bank (b) Gene pool
(c) Gene erosion (d) All of these

217. Loss of some genes from gene pool as a result of deforestation, urban expansion, etc., is:
(a) Gene bank (b) Genetic drift
(c) Genetic erosion (d) Transversions

218. Maintenance of genetic diversity in natural reserves like national parks, etc., is called:
(a) *Ex situ* conservation (b) *In situ* conservation
(c) Gene pool (d) None of these

219. Resistance to late blight disease in potato has been introduced from:
(a) *Solanum ocaule* (b) *S. spegazzani*
(c) *S. demissum* (d) *S. stoloniferum*

220. Resistance to different viral and fungal diseases in sugar cane has been introduced from:
(a) *Saccharum officinarum* (b) *S. munja*
(c) *S. spontaneum* (d) All of these

221. The plant having recalcitrant seeds is:
(a) Litchi (b) Tea
(c) Rubber (d) All of these

222. The plants with recalcitrant seeds can be conserved by:
(a) *Ex situ* conservation (b) *In situ* conservation
(c) Both (a) and (b) (d) None of these

223. An important rice variety, which is widely cultivated in world and has solved food problem in Asia upto great extent, is:
(a) Dee-geo-woo-gen (b) IR-36
(c) Jaya (d) All of these

224. A new crop called *Triticale* is not suitable for making bread due to:
(a) Low protein content (b) Low gluten content
(c) Low starch content (d) All of these

225. Barley, coffee and sorghum are natives of:
(a) Afghanistan (b) Brazil
(c) Ethiopia (d) Peru

226. Who is known as father of green revolution?
(a) Vavilov (b) N. Borlaug
(c) Swaminathan (d) G.H. Khush

227. Which of the following was awarded Nobel Peace Prize (1970) for production of highly productive dwarf wheat varieties?
(a) Borlaug (b) Vavilov
(c) M.S. Swaminathan (d) None of these

228. Father of green revolution in India is: **(MPPMT 1999)**
(a) B.P. Pal (b) M.S. Swaminathan
(c) T.S. Venkatraman (d) Chaudhary Ram Dhan

229. A fast growing small legume tree with edible unripe fruits and seeds, is:
(a) *Leucaena* (b) Winged bean
(c) Guayule (d) None of these

230. Source of Paraguay tea is:
(a) Leaves of *Caltha* (b) Leaves of *Ilex*
(c) Seeds of *Cola* (d) None of these

231. Famous plant which has China as its centre of origin, is:
(a) Tea (b) Maize
(c) Cotton (d) Coffee

232. High yielding dwarf genes from Taiwan in rice are:
(a) Norin-10 (b) Dee-geo-woo-gen
(c) Nif genes (d) None of these

233. A liquid wax, similar to sperm whale oil (spermaceti), which can reduce pressure on sperm whales, is obtained from:
(a) *Parthenium* (b) *Leucaena*
(c) *Psophocarpus* (d) *Simmondsia*

234. The crop which has its centre of origin in tropical America but is being produced on large scale in midwest U.S.A., is:
(a) Maize (b) Rice
(c) Wheat (d) Pineapple

235. 'Chua oil' is obtained from:
(a) *Shorea robusta* (b) *Cola nitida*
(c) *Ilex paraguariensis* (d) *Moringa*

236. Crop cultivation started in:
(a) Northern planes of India (b) Nile
(c) River valley of China (d) All of these

237. Oldest cultivated fruit is:
(a) Apple (b) Banana
(c) Coconut (d) Mango

238. *Triticale* is used:
(a) For bread making (b) For forage
(c) As medicine (d) None of these

239. Genetic erosion is caused by:
(a) Adoption of genetically uniform varieties of crops
(b) Shifting cultivation
(c) Deforestiation
(d) All of the above

240. Progeny of a cross made between two pure parents show increased vigour and productivity. This is due to: **(MPPMT 1991)**
(a) Selection (b) Hybridization
(c) Hybrid Vigour (d) Mutation

241. Resistance to potato virus - X was conferred upon potato from: **(DPMT 1990)**
(a) *Solanum demissum* (b) *Solanum stoloniferum*
(c) *Solanum spergazzani* (d) *Solanum ocaule*

242. The native place of *Hevea* rubber is:
(a) South-East Asia (b) Brazil
(c) Peruvian Andes (d) Malaysia

243. Which of the following is more suitable place for germplasm collection?
(a) Peru (b) France
(c) Britain (d) Brazil

244. Hybrids are generally:
(a) Weak (b) Strong
(c) Like the parents (d) Mutants

245. Agriculture originated in: **(BHU 2001)**
(a) 1700–23,000 years ago (b) 27,000–33,000 years ago
(c) 7,000–13,000 years ago (d) 700–1300 years ago

246. Improvement of crops by means of preserving germplasm in frozen state is called: **(MPPMT 1994)**
(a) Cryopreservation
(b) Cold storage preservation
(c) Vernalization
(d) *In situ* preservation

247. The dwarf varieties of wheat brought from Mexico into India were:
(a) Sonora-64 and Sonalika
(b) Sonora-64 and Lerma Rojo-64
(c) Sharbati Sonora and Pusa Lerma
(d) Sonalika

248. Exchange of germplasm is carried preferably through shoot tip culture because they are:
(a) Generally stable (b) Small and handy
(c) Virus free (d) Cost is very low

249. The name of *Ginkgo* tree has now been removed from the list of endangered plants as a result of:

(a) *In situ* conservation (b) *Ex situ* conservation
(c) Offsite collection (d) Gene bank

250. Naturally occurring mutation in nature as an example of rice strain is: (Raj. PMT 1990)
(a) Padma (b) Jaya
(c) Thychungnative (d) GEB 24

251. In a gene bank, genetic material is stored in the form of:
(a) Seeds (b) Vegetative material
(c) Both (a) and (b) (d) None of these

252. Banana plants can be multiplied rapidly by adopting: (EAMCET 1990)
(a) Aerial grafting (b) Aerial stem cutting
(c) Rhizome cutting (d) X-ray irradiation of fruits

253. An orthodox seed can:
(a) Tolerate dehydration and freezing
(b) Tolerate dehydration but not freezing
(c) Tolerate freezing but not dehydration
(d) None of the above

254. Exploration of under-utilised plant is being done to:
(a) Increase our knowledge
(b) Conserve germplasm
(c) Increase our resource base
(d) None of the above

255. Potato and tomato are natives of:
(a) Canada (b) North America
(c) China (d) South America

256. The number of wheat varieties collected by Vavilov was:
(a) 260 (b) 1260
(c) 2600 (d) 26,000

*257. Dwarf wheats were developed by:
(a) Vavilov (b) Borlaug
(c) Swaminathan (d) None of these

258. Germ plasm is contained in:
(a) Reproductive cells (b) Somatic cells
(c) Both (a) and (b) (d) None of these

259. One of the plants introduced from old world to new world is:
(a) Potato (b) Rice
(c) Sweet potato (d) Maize

260. Which of these is not correctly matched?
(a) Wheat—Persia
(b) Cauliflower—Mesopotamia
(c) Pineapple—Brazil
(d) Paddy—India

261. Vavilov's centres of origin of crop plants are located in:
(a) Mountains of tropical areas
(b) Mountains of temperate areas
(c) Mountains of both tropical and temperate areas
(d) Plains of tropical areas

262. *Triticale* is a man-made cereal which has been developed through hybridization between:
(a) Wheat and Gram (b) Wheat and Rye
(c) Wheat and Oat (d) Wheat and Rice

263. The original home of rice is:
(a) Mediterranean region (b) South-West Asia
(c) South-East Asia (d) China

264. Pre historic man:
(a) Did not cultivate crops at all
(b) Cultivated crops on mountains
(c) Cultivated crops near forests
(d) Cultivated crops near river

265. Which of these is a new crop?
(a) Soybean (b) Winged bean
(c) Sugar beet (d) Lentil

266. One of the plants introduced from new world to old world is:
(a) Potato (b) Sugar cane
(c) Wheat (d) Rice

267. Potato famine of Ireland was caused by the attack of fungus:
(a) *Plasmopara viticola* (b) *Puccinia graminis*
(c) *Phytophthora infestans* (d) *Phytophthora palmivora*

268. Which of these is not correctly matched?
(a) *Leucaena leucocephala* – fixes atmospheric nitrogen
(b) *Psophocarpus tetragonolobus* – seeds are nutritive
(c) *Simmondsia chinensis* – liquid wax is obtained
(d) *Parthenium argentatum* – furniture wood is obtained

269. Which of the following is underutilized oil crop?
(a) *Brassica campestris* (b) *Cocos nucifera*
(c) *Azadirachta indica* (d) None of these

270. Ridley wheat is an example of:
(a) Plant introduction (b) Hybridization
(c) Mass selection (d) Clonal selection

271. The origin of sunflower is believed to be in:
(a) Peruvian Andes
(b) Mexico and central America
(c) Brazil
(d) USA

272. Liquid wax can be obtained from:
(a) Guayule (b) Jojoba
(c) Winged bean (d) All of these

273. The centre of origin of wheat is:
(a) South-East Asia
(b) South-West Asia
(c) Asia minor and Afghanistan
(d) None of the above

274. An under-utilized plant which grows in deserts of Mexico and commonly called 'hohoba' is:
(a) *Psophocarpus tetragonolobus*
(b) *Simmondsia chinensis*
(c) *Leucaena leucocephala*
(d) *Parthenium argentatum*

275. Latex of which plant is alternative of hevea or para rubber?
(a) Subabul (b) Guayule
(c) Jojoba (d) Winged bean

276. Under utilized oil crop is:
(a) *Azadirachta indica* (b) *Shorea robusta*
(c) *Madhuca indica* (d) All of these

277. IR-36 variety of rice is highly resistant to grassy shoot virus. The resistance to this virus in IR-36 has been contributed by:
(a) *Oryza nivara* (b) *O. sativa*
(c) Norin-10 (d) Dee-geo-woo-gen

278. *Ginkgo biloba* is not an endangered species because of its: (MPPMT 1992)
(a) *Ex situ* conservation (b) *In situ* conservation
(c) Offsite conservation (d) Cryopreservation

279. Offsite collections are part of: (MPPMT 1993)
(a) *Ex situ* conservation (b) *In situ* conservation
(c) Both (a) and (b) (d) None of these

280. Which of the following countries is the centre of origin of rice? (MPPMT 1995)
(a) India (b) China
(c) Indo-Malayan region (d) Russia

281. RR-21 is high yielding variety of: (MPPMT 1995)
(a) Rice (b) Wheat
(c) Sugar cane (d) Gram

282. A social forest tree is: (APMEE 1996)
(a) Teak (b) Sandal wood
(c) Subabul (d) Rose wood

283. New world spice that has become an essential part of Indian cuisine is: (CBSE 1995)
(a) Red pepper (b) Black pepper
(c) Cardamon (d) Ginger

284. A plant species threatened with extinction can be preserved in: (CPMT 1996)
(a) Herbarium (b) National park
(c) Botanical garden (d) Gene bank

*285. First man made cereal (*i.e.*, *Triticale*) is:
(a) Octaploid (b) Hexaploid
(c) Both (a) and (b) (d) Diploid

286. Norin-10 gene is:
(a) Dwarf gene of wheat
(b) Dwarf gene of rice
(c) Dwarf gene of tomato
(d) Smut resistant gene of wheat

287. Total number of centres of origin of crop plants given by Vavilov is:
(a) 2 (b) 4
(c) 8 (d) 11

288. A new crop, which is the source of high performance lubricants is:
(a) *Simmondsia chinensis*
(b) *Parthenium argentatum*
(c) *Psophocarpus tetragonolobus*
(d) *Leucaena leucocephala*

289. Seeds of different cereals and legumes are :
(a) Orthodox seeds (b) Recalcitrant seeds
(c) Both (a) and (b) (d) None of these

290. Which is included in bioenergy?
(a) Human muscle power (b) Draught animal power
(c) Both (a) and (b) (d) None of these

291. Human Muscle Power (HMP) accounts for:
(a) 1/3 of total electricity generated in India
(b) 1/5 of total electricity generated in India
(c) Half of total electricity generated in India
(d) None of the above

292. Biofuels are obtained from:
(a) Wood
(b) Agrobased industrial residues
(c) Petrocrops
(d) All of the above

293. Substrate used in biogas production is:
(a) Animal wastes (b) Aquatic plants
(c) Night soil (d) All of these

294. Earliest efforts to cultivate petroplants were made in:
(a) India (b) Ethiopia
(c) China (d) USA

295. Sap of which plant is considered as a good substitute for diesel oil?
(a) *Euphorbia* sps. (b) *Copaifera langsdorfii*
(c) *Calotropis procera* (d) *Manihot glaziovii*

296. Most common petro-crops families are :
(a) Euphorbiaceae and Asclepiadaceae
(b) Leguminosae and Solanaceae
(c) Rutaceae and Malvaceae
(d) Anacardiaceae and Apocynaceae

297. Depleting source of energy is:
(a) Water (b) Wind
(c) Sunlight (d) Fossil fuels

298. Which one of the following is a renewable source of energy? (MPPMT 1995)
(a) Petroleum (b) Coal
(c) Nuclear fuel (d) Trees

299. For biogas production, besides dung which of the following weed is recommended in our country?
(a) *Eichhornia crassipes* (b) *Hydrilla*
(c) *Mangifera indica* (d) *Solanum nigrum*

300. Good firewood must not be:
(a) Highly combustible (b) Non-smoky
(c) Resinous (d) Easy to dry

301. Daily input of sunlight per square meter per day on the earth is:
(a) 100 g cal (b) 400 g cal
(c) 4000 kcal (d) 400 kcal

302. Which of these is a poorer source of fuel wood?
(a) *Acacia nilotica* (b) *Azadirachta indica*
(c) *Pinus roxburghii* (d) *Quercus*

303. Which of the following is a renewable resource? (MDAT Bihar 1995)
(a) Fossil fuel (b) Metal
(c) Water (d) All of these

304. Which of the following source of energy does not cause pollution?
(a) Solar energy (b) Nuclear energy
(c) Coal (d) Wood

305. The population of India is 15% of the world but its annual energy consumption is only:
(a) 0.2% (b) 2.0%
(c) 10% (d) 25%

306. The value of resource depends upon:
(a) Types of society and its needs
(b) Quality of resource
(c) Quantity of resource
(d) All of the above

307. The ultimate source of energy for an ecosystem or aquatic ecosystem is:
(a) Sunlight (b) ATP
(c) DNA (d) Water currents

308. LPG cooking gas is: **(MPPMT 1994)**
(a) Low pressure gas (b) Biogas
(c) Fossil fuel (d) Low price gas

309. The value of extra terrestrial light reaching the biosphere or the value of solar constant is:
(a) 1 g cal/cm^2/min (b) 2 g cal/cm^2/min
(c) 10 g cal/cm^2/min (d) 30 g cal/cm^2/min

310. Example of renewable source of energy is:
(a) Bacteria (b) Fungi
(c) Green plants (d) Crop plants

311. What type of fuel are coal, petrol and natural gas? **(CBSE 1990)**
(a) Biofuels (b) Electrical fuels
(c) Fossil fuels (d) Liquid fuels

312. In which of the following energy occurs?
(a) Leaf (b) Flower
(c) Storages (d) Living cell

313. The energy produced by hydel-power plant is:
(a) Renewable and polluting
(b) Non-renewable and polluting
(c) Renewable and non-polluting
(d) Non-renewable and non-polluting

314. Biogas production rate is limited by:
(a) Production of methane
(b) Digestion of cellulose
(c) Conversion of monomer to organic acids
(d) None of the above

315. Which of the following is a petroleum plant?
(a) *Euphorbia* (b) Potato
(c) Sugar cane (d) Maize

316. Social forestry aims at making available:
(a) Fire wood (b) Fodder
(c) Minor timber (d) All of these

317. The percentage of methane in biogas is:
(a) 70 (b) 90
(c) 7 (d) 20

318. Non-renewable energy resource is: **(CPMT 1994)**
(a) Coal (b) Biomass
(c) Nuclear energy (d) Fire wood

319. Non-renewable substance or resource is: **(Raj. PMT 1992)**
(a) Planktons and fishes (b) Fossils and minerals
(c) Animals and plants (d) Animals and minerals

320. Fuel wood is: **(EAMCET 1990)**
(a) Source of petroleum products
(b) Renewable resource of energy
(c) Source of biogas
(d) Source of alcohol

321. A species selected for energy plantation must not be:
(a) Local (b) Slow growing
(c) Hardy (d) Resistant to pests

322. The energy obtained from 85 million animal power is equivalent to:
(a) 3500 megawatt (b) 30,500 megawatt
(c) 350 megawatt (d) 35,000 megawatt

323. Natural heat of earth is called:
(a) Abiotic energy (b) Bioenergy
(c) Geothermal energy (d) Geographic energy

324. The pioneer country in the production of fuel alcohol is: **(MPPMT 1994)**
(a) Saudi Arabia (b) Iran, Iraq
(c) Brazil (d) Japan

325. Which of the following is more efficient in converting solar energy?
(a) *Chlorella* (b) *Cuscuta*
(c) Earthworm (d) Tiger

326. Petroleum resource is: **(CBSE 1992)**
(a) Renewable
(b) Non-renewable
(c) Synthetic and biodegradable
(d) Infinite and unconventional

327. Transfer of material and energy from one ecosystem to another ecosystem is best exemplified by:
(a) Harvesting of fishes
(b) Grazing of pasture land
(c) Game hunting in savannah
(d) Silvicultural practice on a wood land

328. What % age of radiant energy is stored by producers?
(a) 1.0% (b) 10%
(c) 20% (d) 50%

329. Which of the following is solar energy converter?
(a) *Chlorella* (b) *Mucor*
(c) *Agaricus* (d) *Rhizobium*

330. Which one of these is not correctly matched?
(a) Animal energy—Used most efficiently
(b) Biogas—Produced from dung
(c) Ethanol—Used as gasoline
(d) Latex—Source of liquid hydrocarbon

331. Energy plantations differ from energy croppings in being:
(a) Source of fuelwood (b) Substitute for petroleum
(c) Renewable (d) Exportable

332. Gasohol mixture is useful as:
(a) Fermenter (b) Manure
(c) Automobile fuel (d) All of these

333. Which of the source of energy is non-renewable? **(Raj. PMT 1990)**
(a) Wild life (b) Forest wealth
(c) Coal reserves (d) Hydel-power

334. What percentage of solar radiation is reflected in the outer space by troposphere?
(a) 10% (b) 17%
(c) 34% (d) 90%

335. The energy obtained from biological resources is called: (Raj. PMT 1990)
(a) Electrical energy (b) Mechanical energy
(c) Bioenergy (d) Life energy

336. Thermal power generation is:
(a) Conventional, non-renewable, polluting
(b) Conventional, renewable, polluting
(c) Conventional, renewable, non-polluting
(d) Non-conventional, non-renewable, non-polluting

337. Which one of these is not correctly matched?
(a) Ethanol—Energy cropping
(b) Producer gas—Wood gasification
(c) Methane—Biogas production
(d) Fuel wood—DAP

338. Maximum solar energy can be trapped by:
(a) Growing grasses
(b) Harvesting trees
(c) Planting trees
(d) Cultivation of crops/growing algae in large tanks

339. What average amount of equivalent energy impinges on land in Indian sub-continent (or tropical land)?
(a) 0.5 kWh per sq. metre per year
(b) 1.0 kWh per sq. metre per year
(c) 5.0 kWh per sq. metre per year
(d) 10 kWh per sq. metre per year

340. With the exception of water, which one is possibly the most important accessory chemical substance in industrial process? (CBSE 1994)
(a) Liquid N_2 (b) Ethanol
(c) Petroleum (d) Rubber

341. Besides dung, the weed can be used in biogas production is: (CPMT 1995)
(a) *Hydrilla* (b) *Solanum nigrum*
(c) *Eichhornia crassipes* (d) *Parthenium hysterophorus*

342. Gobar gas contains mainly: (CBSE 1997)
(a) $CH_4 + CO_2$ (b) $CH_4 + O_2$
(c) $CO_2 + H_2$ (d) $CO_2 + H_2O$

343. Consumption of fire wood in India currently is:
(a) 15 m tons (b) 146.5 m tons
(c) 1465 m tons (d) 14,650 m tons

344. Which of the following represents biofuels?
(a) Coal (b) Petroleum
(c) Wood (d) Natural gas

345. Cultivation of more fuel wood trees is known as:
(a) Afforestation. (b) Energy plantations
(c) Energy cropping (d) Deforestation

346. The components of gobar gas (biogas) are:
(a) CO_2, CH_4, SO_2 (b) CH_4, CO_2, H_2
(c) CH_4, CO_2, NO_2 (d) C_2H_6, CO_2, H_2

347. Growing of plants for alcohol production is called:
(a) Energy plantation (b) Energy cropping
(c) Biomass production (d) None of these

348. Pyrolysis of wood is responsible for yielding: (MPPMT 1999)
(a) Alcohol (b) Charcoal
(c) Charcoal and gas (d) Charcoal, gas and oil

349. Producer gas is produced by . . . . of wood:
(a) Carbonization (b) Gasification
(c) Pyrolysis (d) Hydrolysis

350. Producer gas consists of:
(a) CH_4, CO_2, H_2 (b) CO_2, H_2, N_2
(c) CO, H_2, N_2 (d) CH_4, H_2, N_2

351. Sources of bioenergy are:
(a) Animal energy
(b) Animal energy and fossil fuels
(c) Biofuels and animal energy
(d) Solar energy and tidal energy

352. More energy is provided by:
(a) Direct burning of cow dung
(b) Burning of biogas obtained from cow dung
(c) Burning of manure obtained from cow dung
(d) Same in all cases

353. Best wood as fuel is:
(a) Hard wood
(b) Highly combustible
(c) Having high calorific value
(d) All of the above

354. Maximum alcohol production is from:
(a) *Solanum tuberosum*
(b) *Saccharum officinarum*
(c) *Beta vulgaris*
(d) *Manihot glaziovii*

355. Which of the following are responsible for bringing about last stage of biogas production?
(a) *Acetobacter* (b) Methanogens
(c) Thermoacidophiles (d) None of these

356. At 50% methane content, calorific value of biogas is:
(a) 429 kcal/m^3 (b) 4,429 kcal/m^3
(c) 42 kcal/m^3 (d) 44,429 kcal/m^3

357. Which is the first step of biogas production?
(a) Conversion of polymers into soluble monomers anaerobically
(b) Conversion of monomers into organic acids
(c) Conversion of polymers into monomers aerobically
(d) Conversion of organic acids into CH_4

358. Energy cropping is the raising of crops like:
(a) Wheat, rice, sorghum
(b) Rice, potato, sugar cane
(c) Beet, maize, potato, sugar cane
(d) None of the above

359. Petroplants were first recognized by: (MPPMT 1999)
(a) Lamarck (b) Darwin
(c) Hatch and Slack (d) M. Calvin

360. Proper and efficient use of biofuels may solve energy problems of developing countries like India, because these are:
(a) Renewable
(b) Cheaper
(c) Pollution free
(d) Present in huge amount as fossils

361. Which is not characteristic of fire wood?
(a) Easy to dry and non-splitting nature on burning
(b) Highly combustible
(c) Free of offensive smell
(d) Low calorific value

362. Gasohol is:
(a) 90% alcohol + 10% petrol
(b) 10% alcohol + 90% petrol
(c) 20% alcohol + 80% petrol
(d) 100% ethanol

363. Most common biofuel, being used nowadays is:
(a) Cellulose (b) Charcoal
(c) Natural gas (d) Fuel wood

364. Most important source of liquid hydrocarbons is:
(a) *Copaifera longsdorfii*
(b) *Euphorbia antisyphilitica*
(c) *Solanum tuberosum*
(d) *Calotropis procera*

365. Main component of garbage of cities is:
(a) Cellulose (b) Lignin
(c) Pectin (d) Lipids

366. Which of the following is the source of both power and manure?
(a) Petroplants (b) Energy plantations
(c) Biogas (d) None of these

367. Antibiotics producing organisms are:
(a) Fungi (b) Actinomycetes
(c) Bacteria (d) All of these

368. The number of antibiotics known today is:
(a) About 100 (b) About 1000
(c) About 7000 (d) About 10,000

369. Monoclonal antibodies are produced by: **(Orissa JEE 2003)**
(a) Fermentation (b) Hybridoma technology
(c) By using vaccines (d) None of these

370. Nobel Prize for hybridoma technology was given to:
(a) Banting and Best (b) Sharpy Shafer
(c) Kohler and Milstein (d) Murray and Peterson

371. An enzyme obtained from calf stomach is used to produce:
(a) Insulin (b) Cheese
(c) Butter (d) Curd

372. Which is not the result of fermentation?
(a) Bread (b) Beer
(c) Dosa (d) Butter

373. Vaccine of smallpox was developed by:
(a) Pasteur (b) Edward Jenner
(c) Funk (d) None of these

374. Vaccines which are result of recombinant DNA technology are called:
(a) First generation vaccines
(b) Second generation vaccines
(c) Third generation vaccines
(d) None of the above

375. Shikonin, a substance produced by plant tissue culture is a:
(a) Red dye used in silk industry
(b) Hormone
(c) Enzyme
(d) Antibiotic

376. Vitamins, we consume daily are: **(AFMC 1995)**
(a) Fat soluble (b) Water soluble
(c) Both (a) and (b) (d) None of these

377. Restriction enzymes are used in genetic engineering because:
(a) They can cut DNA at specific base sequence
(b) They are proteolytic enzymes which can degrade harmful proteins
(c) They are nucleases that cut DNA at variable sites
(d) They can join different DNA fragments

378. Who first of all isolated insulin from dog's pancreas to cure diabetes?
(a) Murray and Peterson (b) Banting and Best
(c) Sharpy Shafer (d) Funk

379. Citric acid is produced from beet molasses by activity of:
(a) *Aspergillus niger* (b) *Penicillium notatum*
(c) *Acetobacter* (d) None of these

380. Vaccine for foot and mouth disease virus is:
(a) First generation vaccine
(b) Second generation vaccine
(c) Third generation vaccine
(d) Fourth generation vaccine

381. The most important animal steroid is:
(a) Progesterone (b) Oestrogen
(c) Testosterone (d) Cholesterol

382. Production of Vitamin C during fermentation involving a wild strain of bacteria was done by:
(a) Mellanby (b) McCallum
(c) Gyorgy (d) None of these

383. Which of the following enzymes is secreted by yeast, responsible for fermentation?
(a) Enolase (b) Dehydrogenase
(c) Zymase (d) Invertase

384. Yeasts are economically important because:
(a) These spread diseases in animals
(b) These spread diseases in plants
(c) These are used in tobacco and tea factories
(d) These are used in bakeries and breweries

385. Antibiotics are:
(a) Medicines (b) Toxins
(c) Plants (d) Syrups

386. Broad spectrum antibiotic is that which: **(AMU 1985)**
(a) Acts on both pathogens and hosts
(b) Acts on all bacteria and viruses
(c) Acts on a variety of pathogenic micro-organisms
(d) Is effective in very small amounts

387. Yeast is used in the production of:
(a) Acetic acid (b) Cheese
(c) Curd (d) Ethyl alcohol

388. The antibiotics obtained from *Streptomyces* are:
(a) Chloramphenicol, erythromycin
(b) Leucomycin, Neomycin
(c) Novobiocin, Spiramycin
(d) All of the above

389. Utilization of biological knowledge for producing materials useful to society is called : (BHU 1990)
(a) Basic biology (b) Technology
(c) Applied biology (d) Biotechnology

390. Which of the following organelle is related to genetic engineering?
(a) Plasmid (b) Plastids
(c) Hybrid vigour (d) Mutations

391. Teminism is the synthesis of DNA on RNA template was observed in:
(a) TMV (b) Rice dwarf virus
(c) Reovirus (d) Rous sarcoma virus

392. A bioreactor refers to:
(a) Fermentation tank
(b) Organisms reacting to a stimulus
(c) Nuclear reactor for biological studies
(d) Tank for biochemical reactions

393. The enzyme diastase was identified by:
(a) S.A. Waksman (b) A. Fleming
(c) Christian Hasen (d) Payen and Persoz

394. Which of the following established the scientific basis of vaccination?
(a) Louis Pasteur (b) Edward Jenner
(c) Cesar Milstein (d) George Kohler

395. *Torulopsis utilis* is:
(a) A food yeast
(b) Employed for synthesis of citric acid
(c) An important intestinal commensal
(d) Micro-organism that yields third generation vaccines

396. Restriction enzyme was discovered by:
(a) Berg (b) Smith and North
(c) Waksman (d) Alexander Fleming

397. Penicillin was discovered by:
(a) Waksman (b) Dubois
(c) Robert Koch (d) A. Fleming

398. In the production of leavened bread the following is used:
(a) Bacterium (b) Yeast
(c) *Rhizopus* (d) None of these

399. Who was the first to isolate streptomycin?
(a) T' wort (b) A. Fleming
(c) S. Waksman (d) R. Koch

400. The bread is soft and porous when the yeast cells are mixed in the lump of wheat flour, because:
(a) Yeast produces benzoic acid
(b) Evolution of CO_2 makes the bread spongy
(c) Yeast is soft and flour also becomes soft
(d) Yeast produces acetic acid and alcohol which give softness to the bread

401. Tissue culture technique has been successfully used for producing: (Raj. PMT 1990)
(a) Alcoholic beverages (b) Cheese
(c) Shikonin (d) Insulin

402. Anti-scurvy vitamin is: (MDAT Bihar 1995)
(a) Vitamin A (b) Vitamin C
(c) Vitamin D (d) Vitamin E

403. Which one of the following is not used in the production of yoghurt? (MPPMT 1995, 2002)
(a) *Streptococcus lactis*
(b) *Streptococcus thermophilus*
(c) *Lactobacillus bulgaricus*
(d) *Acetobacter aceti*

404. A plant raised from a single germinating pollen grain under cultural conditions is referred to as a: (MPPMT 1994)
(a) Tetraploid plant (b) Haploid plant
(c) Diploid plant (d) Polyploid plant

405. Cheese and yoghurt are products of the process: (MPPMT 1994)
(a) Distillation (b) Pasteurization
(c) Fermentation (d) Dehydration

406. In cheese manufacture, micro-organisms are important for: (CBSE 1994)
(a) The development of resistance to spoilage only
(b) The souring of milk only
(c) Both the souring and the ripening processes
(d) The ripening only

407. Milk is converted into curd by: (CPMT 1991)
(a) *Xanthomonas citri* (b) *Bacillus megatherium*
(c) *Acetobacter aceti* (d) None of these

408. Axenic culture is best defined as: (CPMT 1993)
(a) Cell cultures
(b) Cell cultures free from micro-organism
(c) Cell cultures of insectivorus plants
(d) Cell cultures free from other micro-organisms

409. Dextran is used in:
(a) Bleeding (b) Blood preservation
(c) Blood transfusion (d) Blood clotting

410. Terramycin is obtained from:
(a) *Streptomyces venezuelae*
(b) *Streptomyces aureofaciens*
(c) *Streptomyces rimosus*
(d) *Streptomyces griseus*

411. Heating milk or any other liquid at 65°C and then sudden cooling is known as: (CPMT 1991)
(a) Sterilization (b) Pasteurization
(c) Preservation (d) Fermentation

412. The first acid to be produced using fermentation was:
(a) Citric acid (b) Lactic acid
(c) Maleic acid (d) Acetic acid

413. Feulgen reaction is employed to establish the presence of:
(a) DNA (b) RNA
(c) Proteins (d) Lipids

414. Humuline is:
(a) An acid (b) Protein
(c) Carbohydrate (d) Fat

415. In genetic engineering for cutting DNA, which of the following enzyme is used?
(a) RNA polymerase (b) Restriction endonuclease
(c) Ligase (d) Amylase

416. Enzymes can be immobilised by:
(a) Cross-linking enzyme molecules
(b) Covalently attaching to a solid support
(c) Entrapping them in gel
(d) All of the above

417. Utility of fungi for steroid conversion was demonstrated by:
(a) Pasteur and Jaubert (b) Kohler and Milstein
(c) Murray and Peterson (d) Waksman and Woodruff

418. The method of growing micro-organisms as a thin layer on nutrient medium is known as:
(a) Thin layer growth system
(b) Support growth system
(c) Suspended growth
(d) None of the above

419. Rennet is used in: **(MPPMT 2002)**
(a) Fermentation (b) Cheese making
(c) Bread making (d) Synthesis of antibiotics

420. Most of the eubacteriales antibiotics come from:
(a) *Bacillus* (b) *Rhizobium*
(c) *Pseudomonas* (d) *Streptococcus*

421. A compound which is produced by an organism and inhibits the growth of other organisms is called: **(MPPMT 1995)**
(a) Antigen (b) Antibody
(c) Antibiotic (d) Antiallergic

422. Griseofulvin is an antibiotic of:
(a) Fungal origin (b) Bacterial origin
(c) Algal origin (d) Actinomycete origin

423. A plasmid is: **(CPMT 1994)**
(a) Genetic material of a virus
(b) Extrachromosomal DNA in a bacterial cell
(c) Smallest bacterium
(d) Slime mould

424. If all the bacteria and fungi of the world are destroyed then:
(a) All living things will become immortal and there will be no disease left
(b) We shall be unable to obtain any antibiotics
(c) The soil will gradually become depleted of all nitrogen
(d) The world will become packed with dead bodies and excretions of all kinds of living organisms

425. Haploid plants can be obtained by culturing: **(CBSE 1994)**
(a) Young leaves (b) Endosperm
(c) Pollen grains (d) Root tips

426. Waksman was a well known:
(a) Phycologist (b) Bryologist
(c) Pteridologist (d) Soil microbiologist

427. Vitamin B_{12} is produced directly during the course of fermentation by:
(a) *Ashbya gossypii*
(b) *Rhizopus stolonifer*
(c) *Saccharomyces cerevisiae*
(d) *Propionibacteria*

*428. Cells obtained from cancerous tumours are known as:
(a) Hybridomas (b) Myelomas
(c) Lymphocyte (d) Monoclonal cells

429. Streptomycin was first isolated in 1944–45 by:
(a) Leeuwenhoek (b) Burkholder
(c) Alexander Fleming (d) Waksman

430. In *Rous sarcoma* virus the flow of information is:
(a) DNA → RNA → Protein
(b) DNA → Protein → RNA
(c) RNA → DNA → RNA → Protein
(d) RNA → DNA → Protein

431. The enzyme TPA is used to:
(a) Maintain turgor pressure
(b) Strengthen tissues
(c) Increase plasma
(d) Dissolve blood clots

432. Kohler and Milstein developed biotechnology for the production of:
(a) Myelomas (b) Steroid conversion
(c) Monoclonal antibodies (d) Immobilised enzymes

433. The fruit juices turn bitter in taste if they are kept in open place for some time, because of:
(a) Bacteria of the atmosphere react with the juices
(b) Fermentation of the juice by yeast
(c) Some internal factors
(d) All the above three statements are correct

434. Chloramphenicol and erythromycin (broad spectrum antibiotics) are produced by:
(a) *Streptomyces* (b) *Nitrobacter*
(c) *Rhizobium* (d) *Penicillium*

435. First antibiotic isolated was:
(a) Terramycin (b) Neomycin
(c) Penicillin (d) Streptomycin

436. Nobel Prize of 1978 for the discovery of restriction endonuclease was given to:
(a) Crick and Kornberg
(b) Temin and Baltimore
(c) Arber, Nathans and Nirenberg
(d) Holley, Khorana and Nirenberg

437. Germinating barley seeds are employed in preparation of:
(a) Cheese (b) Wine
(c) Beer (d) Lactic acid

438. Hybridomas are employed for:
(a) Synthesis of antibiotics
(b) Killing cancer cells
(c) Synthesis of monoclonal antibiotics
(d) Production of somatic hybrids

439. The antibiotic terramycin is obtained from: (MPPMT 1995)
(a) *Streptomyces griseus* (b) *Streptomyces rimosus*
(c) *Clostridium botulinum* (d) *Streptomyces venezuelae*

440. Fruits, meats, milk, etc., are dried for preservation at room temp. by the process of: (MPPMT 1994)
(a) Dehydration (b) Pasteurization
(c) Freezing (d) Vernalization

441. Triple antigen or DPT is meant for: (AIIMS 1990)
(a) A vaccine against malaria, typhoid and cancer
(b) Mixture of viruses that cause tetanus, diphtheria and whooping cough
(c) A vaccine against polio, rabies and hepatitis
(d) A vaccine against tetanus, whooping cough and diphtheria

442. Haploid plants can be obtained from: (CPMT 1994)
(a) Anther culture (b) Embryo culture
(c) Shoot tip culture (d) Protoplast culture

443. Antibiotics inhibit the growth of or destroy:
(a) Bacteria and fungi
(b) Bacteria and viruses
(c) Bacteria, algae and viruses
(d) Bacteria, fungi and viruses

444. Which one of the following is used in the production of alcohol? (MPPMT 1995)
(a) *Leuconostoc citrovorum*
(b) *Saccharomyces cerevisiae*
(c) *Torulopsis utilis*
(d) *Clostridium botulinum*

445. Streptomycin is produced by:
(a) *Streptomyces venezuelae*
(b) *Streptomyces griseus*
(c) *Streptomyces scoleus*
(d) *Streptomyces fradie*

446. The conversion of cortexolone to prenisolone involves: (AIIMS 1990)
(a) *Hydroxylation*
(b) *Dehydrogenation*
(c) *Hydroxylation, dehydrogenation*
(d) *Dehydrogenation, hydroxylation*

447. Which of these participate in the manufacturing of dextrans?
(a) *Mucor* (b) *Lactobacillus*
(c) *Leuconostoc* (d) *Pseudomonas*

448. Penicillin is an antibiotic:
(a) Narrow spectrum (b) Broad spectrum
(c) Middle spectrum (d) None of these

449. *Streptomyces griseus* gives antibiotic: (CPMT 1991)
(a) Streptomycin (b) Chloromycetin
(c) Terramycin (d) Polymixin

450. When yeast ferments glucose, the products are: (CBSE 1994)
(a) Ethanol and CO_2 (b) Water and CO_2
(c) Ethanol and water (d) Methanol and CO_2

451. Modified antibiotics are manufactured by the technique of: (MPPMT 1994)
(a) Ultrafiltration (b) Ultracentrifugation
(c) Vernalization (d) Genetic engineering

452. Phytotron is: (CPMT 1994)
(a) An apparatus in which plants are grown in controlled condition
(b) In which plants are grown in pathogen-free condition
(c) Both (a) and (b) are correct
(d) Neither (a) nor (b) is correct

453. Rennin used in cheese industry is: (MPPMT 1995)
(a) Antibiotic (b) Alkaloid
(c) Enzyme (d) Inhibitor

454. The number of antibiotics obtainable from *Streptomyces griseus* are:
(a) 10 (b) 20
(c) 30 (d) 40

455. Which organism is useful in the preparation of roquefort cheese?
(a) *Rhizopus* (b) *Yeast*
(c) *Penicillium* (d) *Aspergillus*

456. Hepatitis B vaccine is a:
(a) First generation vaccine
(b) Second generation vaccine
(c) Third generation vaccine
(d) An interferon

457. Pasteurization makes foodstuffs free from :- (BHU 1990)
(a) All vegetative forms of bacteria
(b) Vegetative forms of all pathogenic microbes
(c) All living organisms
(d) All bacteria

458. Which of the following organelles is related with genetic engineering: (CBSE 1994)
(a) Golgi apparatus (b) Lysosomes
(c) Mitochondria (d) Plasmids

459. Genes which confer antibiotic resistance on bacteria are located on: (MPPMT 1995)
(a) Chromosomal DNA (b) Plasmid
(c) RNA (d) Polysome

460. Conversion of sugar into alcohol during fermentation is due to the direct action of: (MPPMT 1994)
(a) Temperature
(b) Micro-organisms
(c) Concentration of sugar solution
(d) Zymase

461. Which of these is not correctly matched?
(a) Vaccines—Immunology
(b) Recombinant DNA—Biotechnology
(c) Ecodegradation—Biopesticides
(d) Solar energy converter—Pest control

462. Humuline is: (MPPMT 2002)
(a) A form of chitin
(b) A powerful antibiotic
(c) A new digestive enzyme
(d) Human insulin

463. *Streptomyces venezuele* is used to obtain:
(a) Chloromycetin (b) Streptomycin
(c) Tetracycline (d) Aureomycin

464. Genes for antibiotic resistance are located in: **(BHU 1995)**
(a) Chromosome (b) Nucleus
(c) Cell wall (d) Plasmid

465. The term 'antibiotic' was coined by: **(CBSE 1994)**
(a) Alexander Fleming (b) S. Waksman
(c) Louis Pasteur (d) Edward Jenner

466. Auxotroph for lysine will grow: **(CPMT 1994)**
(a) In the presence of lysine
(b) In the absence of lysine
(c) In a solution of any amino acid
(d) In a solution of all amino acids

467. Antibiotic active against *Mycobacterium tuberculosis* is:
(a) Terramycin (b) Streptomycin
(c) Chlorellin (d) Usnic acid

468. Streptomycin is useful for treatment of pathogens: **(CPMT 1994; MPPMT 1994)**
(a) Gram (+) (b) Gram (–)
(c) Both (a) and (b) (d) Gram neutral

469. Yeast yields: **(CPMT 1994)**
(a) Vitamin B_{12} (b) Tocopherol
(c) Riboflavin (d) Ascorbic acid

470. Fermentation of sugar to yield alcohol is carried out by: **(CPMT 1994; MPPMT 1994)**
(a) Micro-organism (b) Zymase
(c) Raised temperature (d) Decomposition of sugar

471. Who obtained interferon through recombinant *E. coli*?
(a) Charles Weisman (b) Banting and Best
(c) Kohler (d) Milstein

472. Curd, milk, cheese and butter are produced with the use of: **(Orissa JEE 1995)**
(a) Yeast (b) *Penicillium*
(c) *Streptococcus* (d) None of these

473. Vinegar is prepared from alcohol with the help of:
(a) *Lactobacillus* (b) *Acetobacter*
(c) *Azotobacter* (d) *Rhizobium*

474. Which one is not used in the production of yoghurt? **(MPPMT 1995)**
(a) *Streptococcus lactis*
(b) *Streptococcus thermophilus*
(c) *Lactobacillus bulgaricus*
(d) *Acetobacter aceti*

475. Distillation of wine is necessary as it: **(CPMT 1996)**
(a) Increases quality
(b) Prevents further fermentation and spoiling of wine
(c) Decreases toxicity
(d) Has no action on nature

476. Biotechnology is: **(DPMT 1996)**
(a) Technology used in biology
(b) Use of genetic engineering
(c) Development of technology for medical application
(d) Use of micro-organism in industrial process

477. Interferon is: **(CPMT 1996; CBSE 1996)**
(a) Antiviral (b) Antibacterial
(c) Antianimal cell (d) Bacterium

478. Distribution of clean and quality milk throughout the world has been made possible through work of: **(AIIMS 1996)**
(a) Leeuwenhoek (b) Koch
(c) Pasteur (d) Blackman

479. Which is false about antibiotics? **(CBSE 1996)**
(a) Coined by Waksman
(b) Produced by micro-organism
(c) Produce allergy in some persons
(d) Cure all diseases

480. Anaerobic respiration of yeast produces: **(CBSE 1996)**
(a) Alcohol
(b) Carbon dioxide
(c) Alcohol, carbon dioxide, beer, wine and other beverages
(d) None of the above

*481. First hormone produced artificially by culturing bacteria: **(CBSE 1996)**
(a) Insulin (b) Thyroxine
(c) Testosterone (d) Adrenaline

482. Heat kills all organism in the process called: **(AFMC 1996)**
(a) Immunity (b) Sterilization
(c) Pasteurization (d) None of these

483. Pasteurization is heating at: **(CBSE 1996)**
(a) 120°C for 20 minutes (b) 60–70° for 30 minutes
(c) 40°C for 30 minutes (d) 80°C for 30 minutes

484. Antiviral substance produced by vertebrates in case of viral infection is: **(AFMC 1996)**
(a) Virion (b) Interferon
(c) Antigen (d) Antivirin

485. The end products of fermentation are: **(CBSE 1997)**
(a) O_2 and C_2H_5OH (b) CO_2 and C_2H_5OH
(c) CO_2 and O_2 (d) CO_2 and acetaldehyde

486. Enzyme streptokinase is used:
(a) For treatment of bacterial diseases
(b) In formation of cheese
(c) For dissolving blood clots
(d) Clearing fruit juices

487. Synthetic vaccines are called:
(a) First generation vaccines
(b) Second generation vaccines
(c) Third generation vaccines
(d) Fourth generation vaccines

*488. Immobilization of an enzyme is advantageous as it protects enzyme against:
(a) Attack by amylases (b) Attack by proteases
(c) High temperature (d) Low temperature

489. The enzyme used for making detergent is:
(a) Proteases (b) Amylases
(c) Lactases (d) None of these

490. Which is not a product of biotechnology?
(a) Steroid (b) Insulin
(c) Vaccines (d) None of these

491. Total number of enzymes on record today is:
(a) About 1000 (b) About 2200
(c) About 3000 (d) About 5200

492. Ascorbic acid (Vitamin C) is produced from L-sorbose by action of:
(a) *Acetobacter* (b) *Azotobacter*
(c) *Lactobacillus* (d) None of these

493. Formation of dextran as a result of polymerization of simple sugars occurs by activity of:
(a) *Rhizopus* (b) *Streptococcus*
(c) *Leuconostoc* (d) None of these

494. Complex carbohydrate cannot be fermented by yeast due to lack of sufficient amount of:
(a) Maltase (b) Protease
(c) Diastase/amylase (d) Sucrase

495. Wine and beer are produced directly by fermentation, brandy and whisky require both fermentation and distillation because: (CBSE 1992)
(a) Fermentation is inhibited at an alcohol level of 10–18%
(b) Distillation prolongs storage
(c) Distillation improves quality
(d) Distillation purifies the beverage

496. Hybridomas are formed by fusion of:
(a) Abnormal antibody producing lymphocytes with myeloma cells
(b) Normal antibody producing lymphocytes with myeloma cells
(c) Reproductive cells with myeloma cells
(d) None of the above

497. Humulin is:
(a) Insulin synthesized in *E. coli* by injecting human insulin gene by recombinant DNA technology
(b) Artificially synthesized interferon
(c) Artificially synthesized growth hormone
(d) None of the above

498. Manipulation of gene or genetic engineering has been made possible because of:
(a) Discovery of restriction enzymes
(b) Development of method for production of DNA having desirable genes
(c) Both (a) and (b)
(d) None of the above

499. 'Clone' is:
(a) A group of cells with different genotypes
(b) A group of cells with identical genotype derived from a single cell
(c) A number of individuals living together
(d) Undifferentiated mass of cells

500. Vectors or carriers used to carry recombinant DNA in genetic engineering are:
(a) Plasmids
(b) Bacteriophages
(c) Plant and animal viruses
(d) All of the above

*501. Best material for gene manipulation is:
(a) Pollen (b) Embryo
(c) Protoplast (d) None of these

502. Farmers have reported over 50% higher yields of rice by using the biofertilizer:
(a) Cyanobacteria
(b) *Azolla pinnata*
(c) Legume– *Rhizobium* symbiosis
(d) Mycorrhiza

503. Which one of the following is non-symbiotic biofertilizer? **(CBSE 1998)**
(a) VAM (b) *Azotobacter*
(c) *Anabaena* (d) *Rhizobium*

504. Which of the following pesticides is an acetyl choline esterase inhibitor? **(CBSE 1998)**
(a) Aldicarb (b) Y-BHC
(c) Endosulphan (d) Malathion

505. Biological control component is control to advanced agricultural production. Which of the following is used as a third generation pesticide? **(CBSE 1998)**
(a) Insect hormone analogue (b) Insect repellants
(c) Pheromones (d) Pathogens

506. Genetic drift operates only in: **(CBSE 1998)**
(a) Island population (b) Smaller populations
(c) Larger populations (d) Mendelian populations

507. The chemical knives of DNA are: **(CBSE 1998)**
(a) Ligases (b) Polymerases
(c) Endonucleases (d) Transcriptases

508. Two bacteria found to be very useful in genetic engineering experiments are: **(CBSE 1998)**
(a) *Nitrosomonas* and *Klebsiella*
(b) *Escherichia* and *Agrobacterium*
(c) *Nitrobacter* and *Azotobacter*
(d) *Rhizobium* and *Diplococcus*

509. Yeast *Saccharomyces cerevisiae* is used in the industrial production of: **(CBSE 1998)**
(a) Butanol (b) Citric acid
(c) Tetracycline (d) Ethanol

510. Which of the following micro-organisms is used in production of citric acid in industries? **(CBSE 1998)**
(a) *Lactobacillus bulgaricus*
(b) *Penicillium citrinum*
(c) *Aspergillus niger*
(d) *Rhizopus nigricans*

511. Recombinant DNA is achieved by cleaving the pro-DNA's by: **(CBSE 1998)**
(a) Primase (b) Exonuclease
(c) Ligase (d) Restriction endonuclease

512. Genetic engineering is possible because: **(CBSE 1998)**
(a) The phenomenon of transduction in bacteria is well understood
(b) We can see DNA by electron microscope
(c) We can cut DNA at specific sites by endonucleases like DNAase I
(d) Restriction endonucleases purified from bacteria can be used *in vitro*

513. The reason why vegetatively reproducing crop plants are best suited for maintaining hybrid vigour is that: **(CBSE 1998)**

(a) They can be easily propagated

(b) Once a desired hybrid has been produced, there are few chances of loosing it

(c) They have a longer life span

(d) They are more resistant to diseases

***514.** Quarantine regulation are concerned with: **(AFMC 1998)**

(a) Spraying of diseased plants with insecticide

(b) Prevention of entry of diseased plants in country

(c) Growing of fruit trees in every state

(d) Promotion of dry farming in sandy soil

515. Biotin and pantothenic acid belong to: **(CBSE 1999)**

(a) Amino acids (b) Vitamin B group

(c) Pyrimidines (d) Steroids

516. Which of the following pairs is mismatched? **(CBSE 1999)**

(a) Vitamin A—Xerophthalmia

(b) Vitamin C—Scurvy

(c) Vitamin K—Beri-beri

(d) Vitamin D—Rickets

517. *Azolla pinnata* is an excellent biofertilizer for: **(CBSE 1999)**

(a) Rice (b) Wheat

(c) Sugar cane (d) Groundnut

518. Best method for conservation of plant genetic resources is to: **(CBSE 1999)**

(a) Preserve their genes in gene library

(b) Preserve them as seeds under dry conditions

(c) Seeds cryopreservation

(d) Maintain them where they are in wild places like forests

519. An economical environment friendly method with minimum input for storing solar energy is: **(CBSE 1999)**

(a) By large scale growing of sugar cane and then burning it to produce electricity

(b) By energy plantation

(c) Electricity generation from sunlight

(d) Use of photovoltaic cells

***520.** Which pesticide gets quickly deposited in mammalian body for a long duration? **(CBSE 1999)**

(a) Fungicides

(b) Rodenticides

(c) Organophosphorus compounds

(d) Chlorinated hydrocarbons

521. Which insecticide is more stable in environment? **(CBSE 1999)**

(a) Malathion (b) DDT

(c) Diazinon (d) Camphochlor

522. The first transgenic plant released for commercial use was: **(CBSE 1999)**

(a) Cotton (b) Tomato

(c) Tobacco (d) Rice

523. Anaerobic digestion of cow dung and agricultural wastes for biogas production utilizes which organism? **(CBSE 1999)**

(a) *Alternaria* (b) *Fusarium*

(c) *Methanobacterium* (d) *Aspergillus*

524. 'Dolly', the sheep was obtained by a technique as: **(CBSE 1999)**

(a) Cloning by gene transfer

(b) Cloning without the help of gametes

(c) Cloning by tissue culture of somatic cells

(d) Cloning by nuclear transfer

525. Recombinant DNA technology can be used to produce large amounts of biologically active form of which product in *E. coli*? **(CBSE 1999)**

(a) Interferon (b) Rifamycin

(c) Luteinizing hormone (d) Ecdysone

526. Hybridoma refers to: **(CBSE 1999)**

(a) DNA–DNA hybridized molecules

(b) Fused gametic cells of two opposite sexes, one derived from a tumour-bearing patient

(c) Fused somatic cells of different types, one derived from a tumour

(d) DNA–RNA hybrid molecule

527. At present, most significant cause dwindling biodiversity is probably: **(CBSE 1999)**

(a) Deterioration of ozone layer

(b) Global warming

(c) Destruction of habitat

(d) Biological magnification of DDT

528. Vaccines are: **(CBSE 1999)**

(a) Heated bacteria or viruses or one of their proteins

(b) MHC (Major Histocompatibility Complete proteins)

(c) Curative medicines

(d) Monoclonal antibodies

529. Terminator technology is used to: **(BHU 1999)**

(a) Terminate growth of plant

(b) Obtain seedless fruits

(c) Terminate polypeptide chain formation

(d) Production of genetically improved variety of seeds which yield sterile seeds is next generation

530. Ectomycorrhiza is present in pine, oak and: **(AIIMS 1999)**

(a) Cycas (b) Orchid

(c) Eucalyptus (d) None of these

531. Most of the petrocrops belong to family: **(MPPMT 1999)**

(a) Leguminosae (b) Euphorbiaceae

(c) Rutaceae (d) Malvaceae

532. Which of the following is commonly used bacteria in plant genetic engineering? **(CBSE 2000)**

(a) *E.coli* (b) *Agrobacterium*

(c) *Mycobacterium* (d) *Rhizobium*

533. Ethyl alcohol is commercially obtained from: **(CBSE 2000; MPPMT 2001)**

(a) *Aspergillus* (b) *Saccharomyces*

(c) *Penicillium* (d) None of these

534. Unlike chemical control of pest, biological control is: (CPMT 2000)
(a) Polluting (b) Expensive
(c) Self perpetuating (d) Toxic

535. Third generation pesticides are: (AFMC 2000)
(a) DDT (b) Juvenile hormone
(c) Pheromones (d) Analogue animal hormone

536. Which cell is totipotent? (AFMC 2000)
(a) Meristematic cell (b) Cork cell
(c) Xylem vessel (d) Fibres

537. Germinating barley seeds are used in preparation of: (MPPMT 2000)
(a) Cheese (b) Wine
(c) Beer (d) Lactic acid

538. Haploid plants can be obtained by culturing: (MPPMT 2000)
(a) Young leaves (b) Endosperm
(c) Pollen grain (d) Root tip

539. The biofertilizer present in root nodules of non-leguminous plants is: (BHU 2000)
(a) *Azotobacter* (b) *Clostridium*
(c) *Frankia* (d) *Rhizobium*

540. In high yielding hybrid crop varieties to exploit hybrid vigour, the farmers need to purchase fresh hybrid seeds every year because: (BHU 2000)
(a) They are not allowed to grow their own seed
(b) Hybrid vigour is not long lasting due to inbreeding depression
(c) Government has accepted Dunkels proposals
(d) It is always associated with increased heterozygosity

541. What are the main objectives of plant breeding? (MPPMT 2001)
(a) More yield (b) Better quality
(c) Stress resistance (d) All of these

542. Cheese is prepared from: (MPPMT 2001)
(a) *Lactobacillus*
(b) *Streptococcus*
(c) *Leuconostoc*
(d) *Streptococcus* and *Lactobacillus*

543. Which is main crop of Asia? (MPPMT 2001)
(a) Wheat (b) Rice
(c) Maize (d) Barley

544. Mycorrhiza is useful for the plants mainly due to: (BHU 2001)
(a) Fixing atmospheric nitrogen
(b) Killing insects and pathogens
(c) Providing resistance for abiotic stresses
(d) Enhanced absorption of nutrients from soil

545. Which of the following is a social foresting species with multiple utility? (BHU 2001)
(a) *Mangifera indica* (b) *Rosa grandiflora*
(c) *Borassus flabelliformis* (d) *Leucaena leucocephala*

*546. Immobilised enzymes are generally used for bioreactors in: (AIIMS 2001)
(a) Batch process (b) Digestive process
(c) Activation process (d) Continuous process

547. Zymase converts: (CPMT 2001)
(a) Glucose $\longrightarrow$ Ethyl alcohol + CO_2
(b) Fructose $\longrightarrow$ Glucose
(c) Sucrose $\longrightarrow$ Glucose + fructose
(d) Sucrose $\longrightarrow$ Ethyl alcohol

548. Invertase converts: (CPMT 2001)
(a) Sucrose $\longrightarrow$ Glucose + fructose
(b) Glucose $\longrightarrow$ Ethyl alcohol + CO_2
(c) Sucrose $\longrightarrow$ Glucose + galactose
(d) None of the above

549. Sum of all the genes in a population is known as: **(Uttaranchal PMT 2001)**
(a) Genome (b) Gene pool
(c) Gene bank (d) Germplasm

550. What is true for monoclonal antibodies? (CBSE 2001)
(a) These antibodies obtained from one parent and for one antigen
(b) These obtained from different parents and for one antigen
(c) These obtained from one parent and for many antigens
(d) These obtained from many parents and for many antigens

551. Which of the following is the pair of biofertilizers? (CBSE 2001)
(a) *Azolla* and BGA (b) *Nostoc* and legume
(c) *Rhizobium* and grasses (d) *Salmonella* and *E.coli*

552. Which statement is correct about centre of origin of plant? (CBSE 2001)
(a) More diversity in improved variety
(b) Frequency of dominant gene is more
(c) Climatic condition more favourable
(d) None of the above

553. Transgenic plants have been produced in:
(a) Mostly dicotyledonous families
(b) Mostly monocotyledonous families
(c) Equally in both dicotyledonous and monocotyledonous families
(d) None of the above

554. In which of the gymnosperms, transgenic plants have been produced?
(a) *Cycas revoluta* (b) *Pinus gerardiana*
(c) *Picea glauca* (d) *Cupressus*

555. 'Flavr Savr' and 'Endless Summer' are transgenic:
(a) Tomatoes (b) Potatoes
(c) Squash (d) Canolas

556. Specific gene transfer in plants is mostly done with:
(a) *Bacillus radicicola*
(b) *Agrobacterium tumefaciens*
(c) *Pseudomonas denitrificans*
(d) *Bacillus megatherium*

557. 'Golden rice' or 'Miracle rice' is transgenic rice rich in: **(Orissa JEE 2003**
(a) Vitamin B and iron
(b) Vitamin A and iron
(c) Vitamin A and Vitamin B
(d) Iron

558. Issues of food safety from GM foods came with studies of:
(a) A. Pusztai (b) M. Lappe
(c) Nordlee (d) None of these

559. Duration of patent in India is:
(a) 17 years (b) 10 years
(c) 5 years (d) 2 years

560. First life form to be patented was:
(a) Oncomouse
(b) Genetically engineered *Pseudomonas*
(c) 'Flavr Savr'
(d) None of the above

561. Which of the following can be protected using patents?
(a) Biological control of pests
(b) Hybrid varieties
(c) Micropropagation technique
(d) Transgenic plants.

562. Patented method for terminator technology is based on a gene called:
(a) RIP gene (b) Onco gene
(c) Brazilnut gene (d) Shrimp gene

563. "India will have to change the patent laws by 2003 to finally open the agriculture sector for patented biotechnology", is suggestion of:
(a) Arther Dunkel of GATT (b) M. Lappe of USDA
(c) Chakrabarty (d) None of these

564. Which of the following is intellectual property right?
(a) Patent (b) Copyright
(c) Trademarks (d) All of these

565. Biopiracy occurs through:
(a) Gene banks (b) Botanical gardens
(c) Both (a) and (b) (d) None of these

566. The theft of plants and ther selling them by getting intellectual property rights without giving any benefits back to the host country (or country of origin), is called:
(a) Biopatenting (b) Biopiracy
(c) Terminator technology (d) None of these

567. Under the discipline 'plant genomics', complete genome of which plant has been sequenced?
(a) Potato (b) *Arabidopsis*
(c) Rice (d) Tomato

568. Which of the following are bioweapons?
(a) Plague bacteria (b) Smallpox viruses
(c) Anthrax bacteria (d) All of these

569. Edible vaccines (antidiarrhoea and cholera vaccines) are contained in genetically engineered:
(a) Potato (b) Tomato
(c) Tobacco (d) None of these

570. "Golden Sela" rice is enriched in:
[BCECE (P.T. Exam.) 2001]
(a) β-carotene (b) Lysine
(c) Vitamin C (d) Iron

571. Emasculation is a part of: **(JIPMER 2002)**
(a) Clonal selection (b) Mass selection
(c) Hybridization (d) Pure line selection

572. Some blue-green algae can be used as biofertilizers because: **(CET Karnataka 2002)**
(a) They have mucilage (b) They are photosynthetic
(c) They fix nitrogen (d) They grow everywhere

573. Haploid plantlets can be produced by:
(CET Karnataka 2002)
(a) Cotyledon culture (b) Pollen culture
(c) Meristem culture (d) Embryo culture

574. An example for *in situ* biological conservation method is to establish: **(CET Karnataka 2002)**
(a) Zoos (b) Biosphere reserves
(c) Seed banks (d) Botanical gardens

575. Confusion technique involves the use of: **(DPMT 2001)**
(a) Juvenile hormone (b) Pheromones
(c) Ecdysone (d) Hormones

576. Potato is native to: **(DPMT 2001)**
(a) South America (b) North America
(c) Southeast Asia (d) Australia

577. Which of the following associations fixes nitrogen through non-nodulation? **(BHU 2002)**
(a) Roots of maize associated with *Spirillum notatum*
(b) Coralloid root of *Cycas* in association with *Anabaena*
(c) Roots of *Digitaria* in association with *Spirillium notatum*
(d) All of the above

578. Curdling of milk in small intestine occurs due to action of:
(AIIMS 2002)
(a) Rennin (b) Trypsin
(c) Eryptine (d) Chymotrypsin

579. Which bacteria are utilized in gobar gas plant?
(CBSE 2002; Kerala PMT 2002)
(a) Methanogens (b) Nitrifying bacteria
(c) Ammonifying bacteria (d) Denitrifying bacteria

580. Which of the following crops have been brought to India from New World? **(CBSE 2002)**
(a) Cashewnut, potato, rubber
(b) Mango, tea
(c) Tea, rubber, mango
(d) Coffee

581. Major threat to wild life is: **(CBSE 2002)**
(a) Destruction of habitat (b) Hunting
(c) Pollution (d) Soil erosion

582. During dough production, bubbles are formed due to action of: **(CBSE 2002)**
(a) Yeast (b) Bacteria
(c) Viruses (d) Protozoans

583. Vitamin B_{12} is produced by: **(MPPMT 2002)**
(a) *Propioni bacterium* (b) *Ashbya gossypii*
(c) *Saccharomyces* (d) *Rhizopus*

584. Antibiotics are: **(Kerala PMT 2002)**
(a) Collective name of useful bacteria
(b) Toxins produced by bacteria
(c) Drugs manufactured to kill viruses
(d) Products of metabolism of bacteria
(e) Bacteria that fix N_2

585. Biofertilizers include: **(CET J & K 2002)**
(a) Nitrogen fixing bacteria
(b) Nitrogen fixing cyanobacteria
(c) Mycorrhiza
(d) All of the above

586. Wax is obtained from: **(CET J & K 2002)**
(a) Jojoba (b) Guayule
(c) *Leucaena* (d) Subabul

587. Which of the following is a recent application of genetic engineering in diagnostic technique? (BHU 2003)
(a) PCR (b) ABC blood groups
(c) ELISA test (d) Gravidex test

588. Pellagra is caused due to deficiency of which vitamin? (BHU 2003)
(a) Vitamin A (b) Vitamin B_1
(c) Vitamin B_3 (d) Vitamin B_{12}

589. Gene library refers to: (Orissa JEE 2003)
(a) DNA sequence information maintained in data bank
(b) DNA fragments maintained in agarose gel
(c) DNA fragments of a genome maintained by cloning in cultured cell
(d) Photographs of DNA fragments printed in books

590. Tumour inducing (Ti) plasmid transforms: (Orissa JEE 2003)
(a) Animals (b) Plants
(c) Bacteria (d) Fungi

591. Restriction endonucleases cut: (Orissa JEE 2003)
(a) Double stranded DNA (b) Single stranded DNA
(c) Single stranded RNA (d) Double stranded RNA

592. Plant cell can be transferred by: (Orissa JEE 2003)
(a) Electroporation (b) Electrophoresis
(c) Electroduction (d) Electrolysis

593. In genetic engineering term vector is applied for: (DPMT 2003)
(a) Plasmid (b) Sources of DNA
(c) Cell which receive (d) Virus

594. The organism which is used for gene transfer in higher organism is: (DPMT 2003)
(a) *Agrobacterium tumefaciens*
(b) *E. coli*
(c) *Acetobacter*
(d) *Bacillus thuringiensis*

595. Niacin deficiency leads to: (DPMT 2003)
(a) Pellagra (b) Oestomalacia
(c) Marasmus (d) Scurvy

596. Biogas produced by anaerobic decomposition used in combustion is mainly due to presence of: (DPMT 2003)
(a) H_2 (b) CH_4
(c) H_2S (d) None of these

597. *Streptococcus* is empolyed in the manufacture of: (DPMT 2003)
(a) Wine (b) Bread
(c) Cheese (d) All of these

598. Cryopreservation is done at temperature: (DPMT 2003)
(a) – 140°C (b) – 120°C
(c) – 196°C (d) – 273°C

599. The enzyme used to cut the DNA molecule is: (Kerala PMT 2003)
(a) Restriction endonucleases
(b) 2-galactosidase
(c) DNA ligase
(d) DNA polymerase
(e) RNA polymerase

600. The specific DNA sequence where EcoRI cuts is: (Kerala PMT 2003)
(a) GATTCG
TAAGCT
(b) GAATTC
CTTAA
(c) GTTCAA
CAAGTT
(d) TTCCAA
AAGCTT

601. An analytical technique that is used in solving dispute based on DNA polymorphism is called: (Kerala PMT 2003)
(a) DNA sequencing (b) DNA fingerprinting
(c) Cloning (d) Cell culture
(e) Somaclonal variation

602. In olden days cheese was prepared by: (BV Pune 2003)
(a) Rennet enzyme (b) *Clostridium* bacteria
(c) *Aspergillus* (d) None of these

603. Which of the bacterium is useful in preparing Idli? (BV Pune 2003)
(a) Clostridium
(b) *Leuconostoc mesenteroides*
(c) Both (a) and (b)
(d) None of the above

604. Cells obtained from cancerous tumour are called: (BV Pune 2003)
(a) Monoclonal cells (b) Lymphocyte
(c) Myelomas (d) Hybridomas

605. Which of the following plants are used as green manure in crop fields and in sandy soils? (CBSE 2003)
(a) *Saccharum munja* and *Lantana camara*
(b) *Crotolaria juncea* and *Alhagi camelorum*
(c) *Calotropis procera* and *Phyllanthus niruri*
(d) *Dicanthium annulatum* and *Azolla nilotica*

606. During anaerobic digestion of organic waste, such as in producing biogas which of the following is left undegraded? (CBSE 2003)
(a) Lignin (b) Lipids
(c) Cellulose (d) Hemicellulose

607. Which of the following bacteria has found extensive use in genetic engineering work in plants? (CBSE 2003)
(a) *Xanthomonas citri*
(b) *Bacillus coagulens*
(c) *Clostridium septicum*
(d) *Agrobacterium tumefaciens*

608. Which of the following bacterial groups are exploited in biogas production? (PMET Punjab 2003)
(a) Eubacteria (b) Methanogen
(c) Organotroph (d) Methanotroph

609. In cross self fertilized plants, the flowers are first emasculated. Which organ of the plant is removed in this process? (PMET Punjab 2003)
(a) Ovary (b) Ovules
(c) Stigmas (d) Stamens or anthers

610. PCR is related with: (PMET Punjab 2003)
(a) DNA cloning
(b) Amplification of DNA

(c) DNA selective replication
(d) All of these

611. Introduction of foreign genes for improving genotype is called: **(PMET Punjab 2003)**
(a) Vernalization (b) Tissue culture
(c) Biotechnology (d) Genetic engineering

612. Which of the following is found in rice field? **(PMET Punjab 2003)**
(a) *Azolla* (b) *Rhizobium*
(c) *Anthoceros* (d) *Rhodospirillum*

613. Azolla has symbiotic relationship with: **(PMET Punjab 2003)**
(a) *Nostoc* (b) *Anabaena*
(c) *Rhizobium* (d) *Azotobacter*

614. Use of biology in industrial process and for improving quality of life is called: **(AFMC 2003)**
(a) Genetic engineering (b) Eugenics
(c) Microbiology (d) Biotechnology

615. Restriction enzymes: **(AIIMS 2003)**
(a) Are endonucleases which cleave DNA at specific sites
(b) Make DNA complementary to an existing DNA or RNA
(c) Cut or join DNA fragments
(d) Are required in vector less direct gene transfer

616. *Azolla* is used as a biofertilizer because it: **(AIIMS 2003)**
(a) Multiplies very fast to produce massive biomass
(b) Has association of nitrogen-fixing *Rhizobium*
(c) Has association of nitrogen-fixing cyanobacteria.
(d) Has association of mycorrhiza

617. Pheromones are basically: **(CMC Vellore 2003)**
(a) Insect hormones (b) Plant hormones
(c) Mammalian hormones (d) Pest repellents

ANSWERS

1—d	2—b	3—c	4—c	5—b	6—c	7—b	8—a	9—a	10—d	11—c	12—c
13—d	14—d	15—a	16—c	17—b	18—d	19—b	20—a	21—c	22—d	23—b	24—c
25—b	26—d	27—c	28—c	29—d	30—c	31—d	32—d	33—d	34—d	35—d	36—a
37—c	38—d	39—c	40—c	41—b	42—b	43—d	44—b	45—c	46—a	47—d	48—a
49—c	50—b	51—c	52—b	53—d	54—b	55—a	56—a	57—c	58—d	59—d	60—d
61—b	62—c	63—b	64—b	65—c	66—d	67—c	68—a	69—c	70—c	71—b	72—d
73—a	74—a	75—b	76—a	77—c	78—b	79—a	80—d	81—b	82—b	83—d	84—b
85—b	86—a	87—b	88—c	89—d	90—d	91—d	92—a	93—c	94—a	95—d	96—c
97—d	98—c	99—c	100—b	101—d	102—b	103—c	104—c	105—b	106—d	107—b	108—a
109—d	110—b	111—b	112—c	113—d	114—a	115—a	116—c	117—a	118—b	119—b	120—d
121—b	122—c	123—d	124—d	125—b	126—d	127—b	128—c	129—c	130—c	131—b	132—a
133—c	134—d	135—c	136—d	137—c	138—c	139—b	140—d	141—d	142—d	143—c	144—a
145—d	146—b	147—d	148—b	149—a	150—b	151—c	152—a	153—a	154—c	155—c	156—b
157—c	158—c	159—b	160—c	161—c	162—b	163—c	164—d	165—d	166—d	167—b	168—c
169—d	170—b	171—b	172—d	173—d	174—c	175—b	176—b	177—a	178—b	179—b	180—b
181—a	182—c	183—a	184—b	185—c	186—c	187—d	188—b	189—c	190—b	191—d	192—d
193—d	194—a	195—d	196—d	197—a	198—d	199—b	200—d	201—c	202—b	203—c	204—b
205—a	206—a	207—c	208—b	209—d	210—d	211—a	212—c	213—c	214—b	215—c	216—b
217—c	218—b	219—c	220—c	221—d	222—b	223—b	224—b	225—c	226—b	227—a	228—b
229—b	230—b	231—a	232—b	233—d	234—a	235—a	236—d	237—c	238—b	239—d	240—c
241—d	242—b	243—a	244—b	245—c	246—a	247—b	248—c	249—b	250—d	251—c	252—a
253—a	254—c	255—d	256—d	257—b	258—a	259—b	260—a	261—a	262—b	263—c	264—a
265—b	266—a	267—c	268—d	269—c	270—a	271—d	272—b	273—b	274—b	275—b	276—d
277—a	278—a	279—b	280—a	281—b	282—c	283—a	284—c	285—c	286—a	287—d	288—a
289—a	290—c	291—b	292—d	293—d	294—b	295—b	296—a	297—d	298—d	299—a	300—c
301—c	302—c	303—c	304—a	305—b	306—a	307—a	308—c	309—b	310—c	311—c	312—d
313—c	314—b	315—a	316—d	317—a	318—a	319—b	320—b	321—b	322—b	323—c	324—c
325—a	326—b	327—a	328—a	329—a	330—a	331—a	332—c	333—c	334—c	335—c	336—a
337—d	338—d	339—a	340—b	341—c	342—a	343—b	344—c	345—b	346—b	347—b	349—d
349—b	350—c	351—c	352—a	353—d	354—b	355—b	356—b	357—a	358—c	359—d	360—a
361—d	362—b	363—d	364—b	365—a	366—c	367—d	368—c	369—b	370—c	371—b	372—d
373—b	374—b	375—a	376—b	377—a	378—b	379—a	380—c	381—d	382—c	383—c	384—d
385—a	386—c	387—d	388—d	389—d	390—a	391—d	392—a	393—d	394—a	395—a	396—b
397—d	398—b	399—c	400—b	401—c	402—b	403—d	404—b	405—c	406—c	407—d	408—d
409—c	410—c	411—b	412—b	413—a	414—b	415—b	416—d	417—c	418—b	419—b	420—a
421—c	422—a	423—b	424—d	425—c	426—d	427—d	428—b	429—d	430—c	431—d	432—c
433—b	434—a	435—c	436—c	437—c	438—c	439—b	440—a	441—d	442—a	443—d	444—b

Contd.

445—b	446—c	447—c	448—a	449—a	450—a	451—d	452—a	453—c	454—d	455—c	456—b
457—b	458—d	459—b	460—d	461—d	462—d	463—a	464—d	465—b	466—a	467—b	468—c
469—c	470—b	471—a	472—c	473—b	474—d	475—b	476—d	477—a	478—c	479—d	480—c
481—a	482—b	483—b	484—b	485—b	486—c	487—c	488—b	489—a	490—d	491—b	492—a
493—c	494—c	495—a	496—b	497—a	498—c	499—b	500—d	501—c	502—b	503—b	504—a
505—c	506—b	507—c	508—b	509—d	510—c	511—d	512—c	513—b	514—b	515—b	516—c
517—a	518—d	519—b	520—d	521—b	522—c	523—c	524—d	525—a	526—c	527—c	528—a
529—d	530—c	531—b	532—b	533—b	534—c	535—c	536—a	537—c	538—c	539—c	540—b
541—d	542—d	543—b	544—d	545—d	546—d	547—a	548—a	549—b	550—b	551—a	552—b
553—a	554—c	555—a	556—b	557—b	558—a	559—c	560—b	561—d	562—a	563—a	564—d
565—c	566—b	567—b	568—d	569—a	570—a	571—c	572—c	573—b	574—b	575—b	576—a
577—d	578—a	579—a	580—a	581—a	582—a	583—a	584—b	585—d	586—a	587—a	588—c
589—c	590—b	591—a	592—a	593—a	594—a	595—a	596—b	597—c	598—c	599—a	600—b
601—b	602—a	603—b	604—c	605—b	606—a	607—d	608—b	609—d	610—d	611—d	612—a
613—b	614—d	615—a	616—c	617—a							

EXPLANATION OF SELECTED QUESTIONS(*)

27. Rotenone is natural insecticide obtained from roots of *Derris* and *Lonchocarpus*.
37. VAM (Vesicular Arbuscular Mycorrhiza) is special type of endomycorrhiza.
49. Biopesticides are eco-friendly and do not cause environmental pollution, *i.e.*, prevent ecodegradation.
69. Concentration of pesticide required to kill 50% of pests is called lethal dose 50 or LD50.
74. Insect hormones are called pherohormones or pheromones which kill insects (*i.e.*, act as bioinsecticides).
75. Death traps are having female pheromones.
87. Root nodules having symbiotic N_2-fixing bacteria in legumes contain a red pigment leghaemoglobin, which help in N_2-fixation.
94. Green manure crops are mostly leguminous.
99. BGA (Blue-green algae) act as good biofertilizer in rice (paddy) fields.
103. Urea contains 46% nitrogen.
155. Embryoids are embryo like structures which are produced by culture of somatic cells in tissue culture technique.
158. Chemical used for fusion of two protoplasts is PEG (Polyethylene glycol).
160. Genetic engineering or recombinant DNA technology is the latest method of crop improvement.
164. Common bread wheat, ***Triticum aestivum*** is hexaploid.
182. Culture without any contamination is called axenic culture.
184. Triploidy is associated with seedlessness and hence seedless varieties of watermelon are triploid.
186. 'Explant' is a single cell or group of cells used for culture in tissue-culture techniques.
213. In centre of origin of a particular plant all grades of variations from wild type species to cultivated types occur.
257. N. Borlaug, a Mexican wheat breeder developed high yielding dwarf wheat varieties.
285. First man-made cereal *Triticale* may be hexaploid or octaploid depending upon the species of wheat used in hybridization with *Secale*.
428. Cells obtained from cancerous tumours are called myelomas or myeloma cells.
481. Insulin is the first hormone produced by culturing *E. coli* bacteria in which insulin producing genes have been transferred from human beings (humuline).
488. Immobilization of enzymes causes stabilization as it protects enzymes against attack of proteases.
501. Best material for gene manipulation is protoplast as due to fragile nature of protoplast, small DNA segments, bacteria, etc., can be incorporated.
514. Quarantine rules or regulations prevent introduction of diseased plant materials in our country.
520. Chlorinated hydrocarbons (*e.g.*, DDT) are non-biodegradable and hence these pesticides get quickly deposited in mammalian body for a long duration.
546. Constant flow of substrate molecules occurs slowly through a bed of immobilized enzymes and hence immobilized enzymes make a continuous process feasible.

TEST PAPER–UNIT–9

1. Epidemic disease producing organisms are killed by:
(a) Herbicides (b) Pesticides
(c) Fungicides (d) Insecticides

2. Pests cause loss of productivity of agriculture upto the extent of:
(a) 10% (b) 20%
(c) 30% (d) 40%

3. The pesticides lipophillic in nature, are:
(a) Organophosphates (b) Organochlorines
(c) Carbamates (d) None of these

4. Methyl Isocyanate (MIC) is the raw material for:
(a) Carbofuran (b) Aldicarb
(c) Carbaryl (d) All of these

5. Largest group of insecticides of plant origin are:
(a) Organochlorines (b) Triazines
(c) Pyrethoids (d) Carbamates

6. 'Pesticide treadmill' is:
(a) Biological magnification of pesticides
(b) Inhibition of photosystem-II of photosynthesis by pesticides
(c) Non-selective mode of action of pesticides
(d) Expense of more money in control of resistant pests

7. *Morrenia odorata* (milkweed vines) in *Citrus* orchards is controlled by bioherbicide:
(a) Collego (b) Devine
(c) Sporeine (d) None of these

8. *Cactoblastis cactorum*, an insect larva is used to control:
(a) Prickly pear cactus (b) Fluted scale insect
(c) Sugar cane scale ~~insect; (d) All of these~~

9. Most useful natural insecticide, which is resistant to about 200 species of pests, is:
(a) Tobacco (b) *Chrysanthemum*
(c) Margosa (d) *Derris*

10. The role of green manures is to:
(a) Provide organic matter and nitrogen to soil
(b) Check soil erosion
(c) Prevent leaching
(d) All of the above

11. Nitrogen fixing bacterium forming a loose association with roots of some grasses, is:
(a) *Rhizobium* (b) *Azotobacter*
(c) *Azospirillum* (d) None of these

12. Mycorrhiza playing significant role in phosphate nutrition of plants is:
(a) Ectotrophic
(b) Endotrophic
(c) VAM (Vesicular-arbuscular mycorrhiza)
(d) All of the above

13. The wild weed plants, which were first brought under cultivation according to Carl Scanner were:
(a) Nitrogen loving (b) Phosphorus loving
(c) Sulphur loving (d) None of these

14. First group of plants which were brought under domestication were:
(a) Legumes (b) Cucurbits
(c) Cereals (d) None of these

15. According to Vavilov, the primary centres of origin of cultivated plants are dominated by:
(a) Recessive genes (b) Dominant genes
(c) Both (a) and (b) (d) None of these

16. The Chile centre of origin is of:
(a) Maize (b) Tobacco
(c) Potato (d) Rubber

17. Groundnut, hevea rubber and cashewnut originated in:
(a) Chile (b) Brazil
(c) Ethiopia (d) Somalia

18. N. Borlaug, Father of green revolution belongs to:
(a) India (b) Russia
(c) Mexico (d) Brazil

19. Crossing of two plants of unlike genetic constitution results in:
(a) Depression (b) Vigour
(c) Vigour remains as such (d) None of these

20. Uncontrolled plant introduction is responsible for introduction of which weed in India?
(a) *Argemone mexicana* (b) *Lantana camara*
(c) *Eichhornia crassipes* (d) All of these

21. Rare hybrids can be saved by:
(a) Pollen culture (b) Embryo culture
(c) Protoplast culture (d) None of these

22. Somaclonal variations are observed in:
(a) Vegetatively propagated plants
(b) Sexually reproducing plants
(c) Plants produced through tissue culture
(d) None of the above

23. Cause of genetic erosion is:
(a) Deforestation (b) Shifting cultivation
(c) Urban expansion (d) All of these

24. Resistance to potato leaf roll virus in potato has been introduced from:
(a) *Solanum ocaule* (b) *Solanum spegazzani*
(c) *Phytophthora infestans* (d) None of these

25. Orthodox seeds are present in:
(a) Cereals (b) Legumes
(c) Both (a) and (b) (d) None of these

26. Rice variety, which is high yielding and has solved food problem in Asia upto great extent, is:
(a) IR–8 (b) IR-36
(c) Norin–10 (d) Sonora–64

27. The plant containing caoutchouc granules, which are ingredient of rubber, is:
(a) *Parthenium* (b) *Leucaena*
(c) *Simmondsia* (d) *Psophocarpus*

28. Plant recommended for social-forestry programme is:
(a) *Leucaena* (b) *Albizzia*
(c) *Anogeissus* (d) All of these

29. The main ingredient of biogas is:
(a) Methane (b) Carbon dioxide
(c) Hydrogen sulphide (d) None of these

30. A Brazilian tree whose sap is good substitute for diesel, is:
(a) *Euphorbia lathyris* (b) *Calotropis procera*
(c) *Copaifera langsdorfii* (d) *Cryptostegia grandiflora*

31. Which of the following is a biotechnology product?
(a) Alcohol (b) Enzymes
(c) Vitamins and antibiotics (d) All of these

32. An enzyme obtained from *Saccharomyces cerevisiae* which is used to prevent sandiness in dairy products, is:
(a) Invertase (b) Cellulase
(c) Pectinase (d) Lactase

33. Special diet prepared by fermentation of milk with *Lactobacillus*, *Streptococcus* and yeast, is:
(a) Insulin (b) Yoghurt
(c) Mabs (d) Myeloma

34. Humuline is:
(a) An edible biotechnological product
(b) A type of antibiotic
(c) A third generation vaccine
(d) Insulin produced by *E. coli* with the help of human genes

35. Antibiotics specific to only one type of antigen are called:
(a) Mabs (b) Hybridomes
(c) Myelomes (d) None of these

36. A dye produced by tissue culture, which is used in silk industry is:
(a) Dextran (b) Roquefort
(c) Camembert (d) Shikonin

37. A pest controlled by release of sterile males is:
(a) Aphid (b) Screw worm
(c) Ladybug (d) Praying mantis

38. Anther name of gammexane is:
(a) BHC (b) Aldrin
(c) 2, 4-D (d) Aldicarb

39. Which of the following is somehow associated with control of malaria?
(a) Praying mantis (b) Cochineal insect
(c) Lady bird beetle (d) Gambusia fish

40. Which is biofertilizer in paddy fields?
(a) BGA (b) Green algae
(c) *Rhizobium* (d) *Azotobacter*

41. Totality of genes in a population is called:
(a) Gene bank (b) Gene pool
(c) Genetic erosion (d) All of these

42. *Streptomyces venezualae* is the source of antibiotic:
(a) Streptomycin (b) Chloromycetin
(c) Chlorellin (d) Terramycin

43. A bioinsecticide 'Rotenone' is obtained from roots of:
(a) *Derris* (b) *Lonchocarpus*
(c) Both (a) and (b) (d) *Azadirachta*

44. Antibodies produced outside the body with the help of hybridoma technology are called:
(a) Myelomas (b) Monoclonal antibodies
(c) Mabs (d) Both (b) and (c)

45. Which of the following is not example of recalcitrant seeds?
(a) *Thea* (b) *Hevea*
(c) *Artocarpus* (d) *Zea*

46. The varieties of wheat introduced from Mexico responsible for green revolution in India are:
(a) IR-8 (b) Sonora-64
(c) Lerma rojo (d) Both (b) and (c)

47. Which is responsible for protoplast fusion in protoplast culture technique of tissue culture?
(a) PEG (b) Cellulase
(c) Pectinase (d) Both (b) and (c)

48. Carotene, precusor of Vit. A is produced by fermentation using:
(a) *Pseudomonas* (b) *Blakslea trispora*
(c) *Glucanobacter* (d) *Bacillus coagulans*

49. A filamentous yeast, *Ashbya gossypii* is source of:
(a) Riboflavin (b) Cobalamine
(c) Ascorbic acid (d) Citric acid

50. A complex polysaccharide dextran is used in:
(a) Plasma transfusion (b) Treatment of burns
(c) Providing immunity (d) None of these

51. Wine is produced by fermentation of :
(a) Grapes (b) Beer
(c) Gin (d) Rum

52. Immobilization of enzymes leads to:
(a) Stabilization of enzymes
(b) Destabilization of enzymes
(c) Either (a) or (b)
(d) None of the above

53. How many transgenic crops have so far been released for cultivation in India?
(a) 60 (b) 50
(c) one (d) Zero

ANSWERS

1—b	2—c	3—b	4—d	5—c	6—d	7—b	8—a	9—c	10—d	11—c	12—c
13—a	14—c	15—b	16—c	17—b	18—c	19—b	20—d	21—b	22—c	23—d	24—a
25—c	26—b	27—a	28—d	29—a	30—c	31—d	32—a	33—b	34—d	35—a	36—d
37—b	38—a	39—d	40—a	41—b	42—b	43—c	44—d	45—d	46—d	47—a	48—b
49—a	50—a	51—a	52—a	53—c							

UNIT-9

ASSERTION AND REASON TYPE QUESTIONS

In the questions given below, two statements—an Assertion (A) and a Reason (R) are given. Give the appropriate response as:

(a) If both A and R are true and R is the correct explanation of A.
(b) If both A and R are true and R is not correct explanation of A.
(c) If A is true but R is false.
(d) If both A and R are false.
(e) If A is false but R is true.

1. **A :** Pesticides are also called biocides.
R : Pesticides kill epidemic disease producing organisms like insects, fungi, weeds, nematodes, rodents, bacteria, etc.

2. **A :** Bordeaux mixture is the first pesticide to be used commercially.
R : Bordeaux mixture was discovered by Bordeaux.

3. **A :** Organochlorines group of pesticides are present in high concentration in fatty tissues of herbivores.
R : Organochlorines are lipophillic in nature.

4. **A :** Malathion is used in large scale control of Malaria.
R : Malathion is important and active constituent of flit.

5. **A :** Use of pesticides disturb the equilibrium state of ecosystem.
R : Pesticides are non-selective in their mode of action.

6. **A :** Triazines are the largest group of insecticides of plant origin.
R : Triazines are commonly used as herbicides.

7. **A :** Sterilization technique is a modern method of biological pest control.
R : In this technique, atmosphere is sterilized with the help of irradiations.

8. **A :** Green manures constitute a category of biofertilizers.
R : Green manures provide both organic matter and nitrogen to soil.

9. **A :** The organisms which enrich the soil in nutrients are called biofertilizers.
R : *Azolla-Anabaena* symbiotic system is the main biofertilizer which is inoculated in wheat fields.

10. **A :** Crossing of two plants of unlike genetic constitution is called hybridization.
R : Hybridization produces new combination of genes but does not change genetic contents of organisms.

11. **A :** Mutation is a method of crop improvement.
R : Stability of mutants is doubtful as some mutants have tendency to revert back to original type.

12. **A :** Some of the plant cells have inherent capacity to develop into complete plant.
R : Tissue culture, is one of the latest and promising methods of crop-improvement.

13. **A :** Most important method of haploid production is pollen culture.
R : Haploid production through pollen culture was first of all made in *Datura innoxia*.

14. **A :** Protoplast culture is a technique of tissue culture.
R : Somatic hybridization is an important use of protoplast culture.

15. **A :** Shoot-meristem culture produces disease free plants.
R : Shoot apical meristems are free of pathogens.

16. **A :** Deforestation, urban expansion and disturbances in ecosystems are causes of genetic erosion.
R : Conservation of plants in wild state is called *ex situ* conservation.

17. **A :** Conservation of germplasm of wild species is very important.
R : Wild species of plants are highly resistant to insects, pests, diseases and unfavourable growth conditions.

18. **A :** The place where different plant materials are kept or preserved, is called gene pool.
R : In a gene pool, storage is done in the form of seeds.

19. **A :** *Parthenium argentatum* is nowadays being used in obtaining rubber.
R : The body of this plant contains caoutchouc granules.

20. **A :** The most important use of plant biotechnology is the production of transgenic plants.
R : First transgenic plants were produced in brinjal.

21. **A :** Specific gene transfer in plants is mostly done with *Agrobacterium tumefaciens* bacteria.
R : In Ti plasmid of *Agrobacterium*, specific genes can be inserted.

22. **A :** Biosafety of transgenic crops is debated.
R : There may be impact of growing transgenic plants on biodiversity.

23. **A :** The foods derived from transgenic crops are called GM foods.
R : Health and food safety concerns have been raised to ensure the safety of GM foods.

24. **A :** Mango and *Pinus* are bad fire woods.
R : These woods are resinous in nature.

25. **A :** Dicots act as better fuel wood than gymnospermous woods.
R : Dicot woods provide uniform heat for a long time.

26. **A :** Growing of crops from which alcohol and other energy fuels can be produced constitute energy cropping.
R : These crops are renewable resources of energy.

27. **A :** In biogas production, water content is maintained at 90%.
R : Methanogenic bacteria involved in biogas production are active at high water content percentage.

28. **A :** Most of the petroplants belong to family Solanaceae.
R : Petroplants are having large amount of latex with long chain hydrocarbons.

29. **A :** Alcohol is a biotechnology product.
R : Alcohol is the result of yeast fermentation.

30. **A :** Stabilization of enzymes is done by immobilization process.
R : Immobilization protects enzymes against attack by proteases.

31. **A :** Insulin is hormone of protein nature made of single polypeptide chain.
R : Insulin can be produced by using recombinant DNA technology for clinical use.

32. **A :** Vaccine of Hepatitis-B is second generation vaccine.
R : This vaccine has been produced by recombinant DNA technology.

33. **A :** Interferons were produced by Weismann through recombinant DNA technology.
R : Interferons are antibacterial proteins.

34. **A :** Mabs are the specialized antibodies, specific to only one type of antigen.
R : Mabs are produced by hybridoma technology.

35. **A :** Terminator technology has been banned by Indian government.
R : Patented method for terminator technology is based on 'RIP' gene.

36. **A :** Transgenic animals and plants cannot be patented.
R : A large number of transgenic crops have been released in India for cultivation.

37. **A :** Yoghurt is a biotechnology product.
R : It is a special diet prepared by fermentation of concentrated milk with *Lactobacillus bulgaricus*, *Streptococcus thermophilus* and yeast.

38. **A :** Winged bean is widely cultivated throughout India.
R : The protein content in the seeds of winged bean is low. **(AIIMS 1996)**

39. **A :** Jojoba is an important drought desert plant.
R : The seeds of this plant contain about 50% liquid wax, similar to sperm whale oil.

40. **A :** Subabul or *Leucaena* is member of family Poaceae.
R : It is most important under-utilized forage crop.

41. **A :** Clones are a group of organisms of identical genotype, produced by same kind of sexual reproduction and same sexual processes.
R : These are prepared by a group of cells descended from many cells or by inbreeding of a completely heterozygous line. **(AIIMS 2002)**

ANSWERS

1. (a) **2.** (c) **3.** (a) **4.** (a) **5.** (a) **6.** (c) **7.** (c) **8.** (b) **9.** (c) **10.** (b)
11. (b) **12.** (c) **13.** (b) **14.** (b) **15.** (a) **16.** (c) **17.** (a) **18.** (d) **19.** (a) **20.** (c)
21. (a) **22.** (a) **23.** (b) **24.** (a) **25.** (a) **26.** (b) **27.** (a) **28.** (c) **29.** (a) **30.** (a)
31. (c) **32.** (a) **33.** (c) **34.** (b) **35.** (b) **36.** (d) **37.** (a) **38.** (c) **39.** (b) **40.** (d)
41. (c)

SELF EVALUATION TEST–I

1. The father of Indian Botany is:
   (a) Father Santapau [✓ (b) E.J. Butler]
   (c) Birbal Sahni (d) William Roxburgh
2. Silviculture is the branch dealing with:
   (a) Silk products
   (b) Silicified plants
   [✓ (c) Forests and their products]
   (d) Plants of tribal use
3. Prof. V. Puri is associated with:
   (a) Embryology (b) Anatomy
   [✓ (c) Morphology] (d) Physiology
4. Study of lawns comprises:
   (a) Anthology (b) Dendrology
   [✓ (c) Agrostology] (d) Pedology
5. Indian botanical garden is located at:
   (a) Lucknow (b) Kanpur
   (c) Kolkata (d) Delhi
6. Which is the age of angiosperms?
   (a) Archeozoic (b) Mesozoic
   (c) Paleozoic [✓ (d) Cenozoic]
7. Which is 'Marine Angiosperm'?
   (a) *Wolffia* (b) *Lodoicea*
   (c) *Raphia* [✓ (d) *Zostera*]
8. Which of the following is considered to be oldest of all cultivated plants?
   (a) Wheat [✓ (b) Barley]
   (c) Rice (d) Maize
9. Ganga-5 is cultivar of:
   (a) Potato (b) Rice
   [✓ (c) Maize] (d) *Cicer*
10. Para rubber is obtained from:
    (a) *Ficus* (b) *Manihot*
    [✓ (c) *Hevea*] (d) *Castilla*
11. Potato is a:
    (a) Old world species [✓ (b) New world species]
    (c) Both (a) and (b) (d) None of these
12. Heaviest wood is of:
    (a) *Ochroma* (b) *Dalbergia*
    [✓ (c) *Guaicum*] (d) *Salix*
13. Source of Liquorice is:
    (a) Roots of *Aconitum* (b) Roots of *Glycyrrhiza*
    (c) Stem of *Glycyrrhiza* (d) Roots of *Atropa*
14. 'Bhojpatra' is obtained from:
    (a) Leaves of *Betula* (b) Bark of *Betula*
    (c) Leaves of *Butea* (d) Bark of *Picea*
15. Red Squill (raticide) is obtained from:
    (a) *Derris* roots (b) *Lonchocarpus* roots
    (c) *Urginea* bulbs (d) *Chrysanthemum* flowers
16. Source of 'Santonin' is:
    (a) *Aloe* (b) *Artemisia*
    (c) *Atropa* (d) *Colchicum*
17. Cauliflory is:
    [✓ (a) Production of flowers on old stem]
    (b) Flowers on young branches
    (c) Flowers in clusters
    (d) None of the above
18. Epicalyx is:
    (a) Additional whorl of calyx
    (b) Involucre
    (c) Whorl of bracts
    [✓ (d) Whorl of bracteoles]
19. The term Taxonomy was given by:
    (a) Theophrastus (b) Bentham and Hooker
    [✓ (c) A. P. de Candolle] (d) Rendle
20. Most advanced family among dicots is:
    (a) Malvaceae (b) Solanaceae
    [✓ (c) Compositae] (d) Cucurbitaceae
21. In racemose inflorescence:
    [✓ (a) Youngest flower at the top]
    (b) Oldest flower at the top
    (c) Youngest in the middle
    (d) Either of the above
22. Which is the natural system of classification?
    (a) Linnaeus classification [✓ (b) Bentham and Hooker's]
    (c) Engler and Prantl's (d) Hutchinson's classification
23. Taxon refers to:
    (a) Species (b) Genus
    (c) Family [✓ (d) Group of any rank]
24. Diadelphous condition is in:
    (a) Caesalpiniaceae (b) Mimosaceae
    (c) Papilionaceae (d) Solanaceae
25. Siliqua develops from:
    (a) Monocarpellary gynaecium
    [✓ (b) Bicarpellary gynaecium]
    (c) Polycarpellary gynaecium
    (d) Thalamus
26. An American plant which is a troublesome terrestrial weed in India is:
    (a) *Eichhornia* (b) *Argemone*
    (c) *Parthenium* (d) *Chenopodium*
27. 'Pappus' are modified:
    (a) Bracts (b) Bracteoles
    [✓ (c) Sepals] (d) Petals
28. Seeds of which are used for weighing by jewellers?
    (a) *Ambrosia* (b) *Atropa*
    [✓ (c) *Abrus*] (d) *Dolichos*
29. Foliaceous stipules are found in:
    (a) Gram (b) Garden pea
    [✓ (c) Sweet pea] (d) *Smilax*
30. Sessile bisexual flowers arranged acropetally constitute:
    (a) Spadix [✓ (b) Spike]
    (c) Raceme (d) Corymb inflorescence

31. *Momordica* is bitter due to:
(a) Steroids (b) Stanozolol
(c) Cucurbitacin (d) Red squill

32. Maximum variation from polyandry to synandry occurs in:
(a) Compositae (b) Liliaceae
(c) Leguminosae (d) Cucurbitaceae

33. Resupination occurs in:
(a) Grasses (b) Orchids
(c) Asteraceae (d) All of these

34. Androecium in Liliaceae is:
(a) Monoadelphous (b) Monothecous
(c) Antiphyllous (d) Alterniphyllous

35. Odd sepal is anterior in:
(a) Cruciferae (b) Malvaceae
(c) Caesalpiniaceae (d) Rutaceae

36. Largest family is:
(a) Poaceae (b) Asteraceae
(c) Fabaceae (d) None of these

37. BOD stands for:
(a) Biotic O_2 Demand (b) Biochemical O_2 Demand
(c) Biosphere O_2 Demand (d) None of these

38. DDT is a:
(a) Biodegradable pollutant
(b) Nondegradable pollutant
(c) Antibiotic
(d) None of the above

39. 'Golden rice' or 'Miracle rice' is:
(a) Rice developed by hybridization
(b) Rice developed by mutation
(c) Transgenic rice
(d) Selected rice

40. Gully erosion is by:
(a) Water (b) Wind
(c) Rivers (d) Grazing

41. Mulching helps in:
(a) Weed control
(b) Moisture conservation
(c) Soil fertility
(d) Improvement of soil structure

42. Solar energy is trapped to maximum extent by:
(a) Wheat (b) Rice
(c) Sugar cane (d) Maize

43. Which is a true xerophyte?
(a) *Asparagus* (b) *Argemone*
(c) *Agave* (d) *Zizyphus*

44. Secchi disc is used to measure:
(a) Temperature (b) Light intensity
(c) Turbidity of water (d) Wind velocity

45. The plants growing in cold soils are:
(a) Oxylophytes (b) Psychrophytes
(c) Halophytes (d) Chasmophytes

46. Latosols are rich in:
(a) Calcium (b) Magnesium
(c) Aluminium (d) Copper

47. Most favoured habitat of plant is:
(a) Ecological system (b) Ecological habitat
(c) Ecological type (d) Ecological niche

48. Ecades are genetically:
(a) Similar (b) Different
(c) Similar or different (d) None of these

49. The chief source of nitrogen for plants in soil is:
(a) Nitrite (b) Nitrate
(c) Free nitrogen (d) NH_3

50. Ozone is formed in:
(a) Stratosphere (b) Mesosphere
(c) Troposphere (d) Ionosphere

51. An interaction in which one population is inhibited and other is not affected, is:
(a) Commensalism (b) Amensalism
(c) Predation (d) Parasitism

52. Process which involves decalcification and leaching of iron and aluminium ores from A-horizon:
(a) Gleization (b) Podsolization
(c) Laterization (d) Calcification

53. The term Ecosystem was given by:
(a) Odum (b) Hult
(c) Grinnel (d) Tansley

54. The term Meristem was given by:
(a) Nageli (b) Hanstein
(c) Grew (d) Malpighi

55. The divisions in 'Tunica' are:
(a) Only periclinal (b) Only anticlinal
(c) Both (a) and (b) (d) None of these

56. Mechanical tissue devoid of lignin is:
(a) Parenchyma (b) Collenchyma
(c) Sclerenchyma (d) Chlorenchyma

57. Growth is subapical in:
(a) Root (b) Shoot
(c) Petiole (d) Pedicel

58. Which is commonly known as starch sheath?
(a) Pericycle (b) Endodermis
(c) Epidermis (d) Hypodermis

59. Centrifugal xylem is feature of:
(a) Root (b) Stem
(c) Both (a) and (b) (d) None of these

60. Isobilateral leaves are:
(a) Hypostomatic (b) Epistomatic
(c) Amphistomatic (d) None of these

61. Complementary cells are associated with:
(a) Lenticels (b) Hydathodes
(c) Rhytidomes (d) Bark

62. Which of the following is not included in 'Archegoniatae'?
(a) Bryophytes (b) Pteridophytes
(c) Gymnosperms (d) Angiosperms

63. Red wood tree is:
(a) *Cedrus* (b) *Pinus*
(c) *Dalbergia* (d) *Sequoia*

64. Male gametophyte is gymnosperms have prothallial cells:
(a) 0 (b) 1
(c) 1 or more (d) 4

65. Endosperm in *Cycas* is:
(a) Generally haploid (b) Always haploid
(c) Triploid (d) With different ploidy levels

66. Number of neck canal cells in archegonium of *Cycas* is:
(a) 2 (b) 4
(c) 6 (d) 0

67. Female cone is absent in:
(a) *Cycas* (b) *Pinus*
(c) *Ephedra* (d) None of these

68. *Cycas* is:
(a) Monoecious (b) Dioecious
(c) Sterile (d) None of these

69. Algal zone is characteristic of:
(a) Normal roots of *Cycas* (b) Coralloid roots of *Cycas*
(c) Stem of *Cycas* (d) Roots of *Pinus*

70. Bryophytes are:
(a) Homosporous (b) Heterosporous
(c) Homo or heterosporous (d) None of these

71. The smallest bryophyte is:
(a) *Dawsonia* (b) *Fontinalis*
(c) *Zoopsis* (d) *Funaria*

72. *Funaria* grows well in:
(a) Soils rich in cow dung
(b) Soils rich in horse dung
(c) Recently burnt soils rich in plant ash
(d) None of the above

73. The main branch in leafy gametophore of *Funaria* is:
(a) Female (b) Male
(c) Either male or female (d) None of these

74. Which is hygroscopic in nature in moss?
(a) Exostome (b) Endostome
(c) Both (a) and (b) (d) None of these

75. Leaves of moss plant contain:
(a) Stomata and chlorophyll
(b) Stomata but no chlorophyll
(c) No stomata but contain chlorophyll
(d) No stomata and chlorophyll

76. Which is absent in moss sporophyte?
(a) Foot (b) Seta
(c) Elaters (d) Columella

77. Vascular cryptogams are:
(a) Algae (b) Fungi
(c) Bryophytes (d) Pteridophytes

78. Medullated protostele is called:
(a) Solenostele (b) Siphonostele
(c) Actinostele (d) Plectostele

79. Fern *Adiantum* is known as:
(a) Quillwort (b) Adder's tongue fern
(c) Hay scented fern (d) Maiden hair fern

80. Meristeles are found in:
(a) Fern leaf (b) Fern rhizome
(c) Fern root (d) None of these

81. The fern prothallus is:
(a) Homothallic (b) Heterothallic
(c) Heterotrophic (d) Heteromorphic

82. 'Red snow' is caused by:
(a) *Chlamydomonas nivalis* (b) *Haematococcus nivalis*
(c) Both (a) and (b) (d) None of these

83. Eye spot in *Chlamydomonas* contains:
(a) Carotenoids (b) Chlorophyll
(c) Haematochromes (d) Xanthophyll

84. The most common method of reproduction in *Spirogyra* is:
(a) Fragmentation (b) Scalariform conjugation
(c) Lateral conjugation (d) All of these

85. Who is associated with study of annual recurrence of wheat rust in India?
(a) Butler (b) Thind
(c) Mehta (d) Mundkar

86. Heterothallism was first observed by:
(a) Magnus (b) Pontecorvo
(c) Blakeslee (d) Alexopaulus

87. Which is the budding yeast?
(a) *Saccharomyces* (b) *Schizosaccharomyces*
(c) Both (a) and (b) (d) None of these

88. Yeasts were first reported by:
(a) Linnaeus (b) Pasteur
(c) Leeuwenhoek (d) Hooke

89. Highly resistant spores in bacteria are:
(a) Chlamydospores (b) Hypnospores
(c) Endospores (d) Akinetes

90. Binary fission does not occur in:
(a) Bacteria (b) Virus
(c) Mycoplasma (d) None of these

91. The fruit developing from complete inflorescence is:
(a) Simple (b) False
(c) Composite (d) Aggregate

92. Banana is:
(a) Berry (b) Pome
(c) Pepo (d) Balausta

93. Ribosomes are attached to endoplasmic reticulum by:
(a) Ribosomal RNA
(b) t-RNA
(c) Hydrophobic interactions
(d) Ribophorines

94. Cystolith is deposition of:
(a) Calcium oxalate (b) Starch
(c) Silica (d) Calcium carbonate

95. Which is called 'store house of RNA'?
(a) Nucleus (b) Chromosome
(c) Nucleolus (d) None of these

96. Core particles are connected by:
(a) Nucleosome (b) Chromomeres
(c) Linker DNA (d) None of these

97. DNA-polymerase enzyme was discovered by:
(a) Khorana (b) Kornberg
(c) Ochoa (d) Bateson

98. Interallelic gene supression is called:
(a) Epistasis (b) Hypostasis
(c) Dominance (d) None of these

99. The CO_2 acceptor molecule in C_3 cycle is:
    (a) PGAL (b) PGA
    (c) PEP (d) RuBP

100. Cell *A* with OP = 6 and WP = 5 is surrounded by cell *B* with OP = 3 and TP = 2. What will be the direction of water movement?
    (a) From *A* → *B* (b) From *B* → *A*
    (c) No movement (d) Water will move up

ANSWERS

1—d	2—c	3—c	4—c	5—c	6—d	7—d	8—b	9—c	10—c	11—b	12—c
13—b	14—b	15—c	16—b	17—a	18—d	19—c	20—c	21—a	22—b	23—d	24—c
25—b	26—c	27—c	28—c	29—c	30—b	31—c	32—d	33—b	34—c	35—c	36—b
37—b	38—b	39—c	40—a	41—b	42—c	43—d	44—c	45—b	46—c	47—d	48—a
49—b	50—a	51—b	52—b	53—d	54—a	55—b	56—b	57—a	58—b	59—b	60—c
61—a	62—d	63—d	64—c	65—b	66—d	67—a	68—b	69—b	70—a	71—c	72—c
73—b	74—a	75—c	76—c	77—d	78—b	79—d	80—b	81—a	82—c	83—a	84—a
85—c	86—c	87—a	88—c	89—c	90—b	91—c	92—a	93—d	94—d	95—c	96—c
97—b	98—a	99—d	100—c								

SELF EVALUATION TEST–II

1. The book 'Historia Plantarum' was written by:
(a) Aristotle (b) Linnaeus
(c) Bentham and Hooker (d) Theophrastus

2. The branch dealing with functional aspects of plants constitute:
(a) Ecology (b) Morphology
(c) Physiology (d) Morphogenesis

3. P. Maheshwari was associated with:
(a) Morphology (b) Embryology
(c) Physiology (d) Cytology

4. N. Borlaug is associated with:
(a) Plant Breeding (b) Morphology
(c) Embryology (d) Physiology

5. The concept of 'Totipotency' was given by:
(a) Steward (b) Hippocrates
(c) Haberlandt (d) None of these

6. Ethanobotany deals with:
(a) Forest products (b) Study of medicinal plants
(c) Plants of tribal use (d) Preservation of germplasm

7. Birbal Sahni Institute of Palaeobotany is located at:
(a) Kolkata (b) Lucknow
(c) Dehradun (d) Delhi

8. Longest leaf occurs in:
(a) *Victoria regia* (b) *Lodoicea*
(c) *Raphia* (d) *Rafflesia*

9. Which is the principal food crop of the world?
(a) Wheat (b) Maize
(c) Rice (d) Barley

10. Largest herbarium in India is of:
(a) F.R.I., Dehradun (b) I.B.G., Kolkata
(c) N.B.G., Lucknow (d) I.A.R.I., New Delhi

11. Angiosperms resemble gymnosperms in:
(a) Nature of endosperm
(b) Presence of ovules
(c) Presence of vessels in wood
(d) Mode of fertilization

12. Citric acid cycle occurs in:
(a) Cytoplasm (b) Mitochondrial matrix
(c) Cristae (d) None of these

13. Efficiency of aerobic respiration is:
(a) 60% (b) 40%
(c) 45% (d) 50%

14. Oxidative phosphorylation of 1 $FADH_2$ yields:
(a) 1 ATP (b) 2 ATP
(c) 3 ATP (d) 0 ATP

15. The respiratory substrate in photorespiration is:
(a) Carbohydrate (b) Protein
(c) Glycolic acid (d) Glyoxylic acid

16. Respiration is a:
(a) Chemical change (b) Mechanical process
(c) Vital process (d) Physical process

17. The phenomenon of 'Red drop' was discovered by:
(a) Emerson (b) Emerson and Lewis
(c) Arnon (d) Blackman

18. Assimilatory power is:
(a) ATP (b) $NADPH_2$
(c) Both (a) and (b) (d) None of these

19. Z-scheme of electron transfer and photophosphorylation was given by:
(a) Arnon (b) Hill
(c) Hill and Bendall (d) Blackman and Hill

20. Immediate electron acceptor from PSI is:
(a) Fd (b) NADP
(c) A (FeS) (d) PQ

21. 'Wreath Anatomy' is feature of:
(a) Temperate grasses (b) Tropical grasses
(c) Conifers (d) None of these

22. Which is not correct for cyclic photophosphorylation?
(a) No O_2 given off
(b) No water consumed
(c) No $NADPH_2$ synthesized
(d) PS–I and PS–II are involved

23. Dark reaction of photosynthesis occurs in:
(a) Presence of light
(b) Absence of light
(c) Presence or absence of light
(d) None of the above

24. C_2 cycle is found in:
(a) C_3 plants (b) C_4 plants
(c) Both C_3 and C_4 plants (d) None of these

25. Rate of photosynthesis is highest in:
(a) Red light (b) Blue light
(c) Green light (d) White light

26. Bacteriochlorophyll absorbs which wavelength of light?
(a) 850–950 nm (b) Upto 680 nm
(c) 720–750 nm (d) None of these

27. Concept of Florigen was given by:
(a) Butler (b) Borthwick
(c) Chailakhyan (d) Allard

28. Which is commonly known as 'Indian pipe'?
(a) *Neottia* (b) *Monotropa*
(c) *Corallorhiza* (d) *Cephalotus*

29. Which is the receptor of photoperiodic stimulus?
(a) Stem (b) Shoot apex
(c) Leaves (d) Apical meristems

30. Full form of NADP is:
(a) Nicotine adenine diphosphate
(b) Nicotinamide adenosine dinucleotide phosphate
(c) Nicotinamide adenine dinucleotide phosphate
(d) Nicotinamide adenine diphosphate

31. The cause of Bakanae disease of rice is:
(a) *Cephaleuros* (b) *Fusarium moniliformae*
(c) Auxins (d) Bacteria
32. Auxins were first isolated from:
(a) Corn germ oil (b) *Rhizopus*
(c) Human urine (d) *Avena* tip
33. Etiolation is related to:
(a) ABA (b) Cytokinin
(c) GA (d) Auxins
34. Paratonic movements of locomotion are:
(a) Tropic movements (b) Nastic movements
(c) Tactic movements (d) None of these
35. D.P.D. =
(a) OP × TP (b) OP + TP
(c) OP – WP (d) TP – WP
36. Girdling experiment was first performed by:
(a) Kramer (b) J.C. Bose
(c) Strasburger (d) Hartig
37. Cell sap is:
(a) Living content of vacuole which controls osmotic relation
(b) Living content of cell which controls osmotic relation
(c) Non-living content of cell
(d) Non-living content of vacuole'
38. Guttation is due to:
(a) OP (b) SP
(c) Root pressure (d) TP
39. Fully opened stomata of leaf occupies what %age of leaf area?
(a) 0.5% (b) 5%
(c) 10% (d) 1–2%
40. Khaira disease of rice is due to:
(a) Fungus (b) Bacteria
(c) Virus (d) Zn deficiency
41. Which of the following is a critical element?
(a) C (b) Mg
(c) K (d) H
42. Chlorophyll is formed in presence of:
(a) Cu and Fe (b) Mo and Cl
(c) Mg (d) Fe and Mg
43. Genetics deals with:
(a) Genes (b) Heredity
(c) Variation (d) Heredity and variations
44. Mendel worked on:
(a) Pigeon pea (b) Garden pea
(c) Sweet pea (d) Chick pea
45. If a plant heterozygous for tallness is selfed, the F$_2$ generation has both tall and dwarf plants. This proves the principle of:
(a) Dominance (b) Segregation
(c) Independent assortment (d) Incomplete dominance
46. When two pairs of genes interact to give 9 : 3 : 4 F$_2$ ratio, they are:
(a) Complementary genes (b) Supplementary genes
(c) Epistatic genes (d) Duplicate genes
47. A cross between a plant heterozygous for two factors and a plant recessive for both characters gives a phenotypic ratio of :
(a) 7 : 1 : 1 : 7 (b) 9 : 3 : 3 : 1
(c) 1 : 1 : 1 : 1 (d) 1 : 7 : 7 : 1
48. The sugar present in DNA is :
(a) Hexose sugar (b) Triose sugar
(c) Pentose sugar (d) Tetrose sugar
49. Short lived RNA is:
(a) t-RNA (b) r-RNA
(c) m-RNA (d) None of these
50. Enzymes involved in DNA-replication are:
(a) RNA-polymerase and DNA- polymerase
(b) RNA-polymerase and Ligase
(c) DNA-polymerase and Ligase
(d) DNA-polymerase only
51. Which is called 'Central dogma'?
(a) DNA → m-RNA ⇌ Proteins
(b) DNA ⇌ m-RNA → Proteins
(c) DNA → m-RNA → Proteins
(d) None of the above
52. Chain initiation codon is:
(a) UGA (b) AUG
(c) GUG (d) AUG or GUG
53. Mutations are mostly:
(a) Dominant (b) Incompletely dominant
(c) Codominant (d) Recessive
54. Which will result in 1 : 2 : 1 F$_2$-ratio?
(a) Yg × gg (b) Yg × Yg
(c) Yg × yy (d) YY × gg
55. Number of linkage groups in bacteria is:
(a) 2 (b) 1
(c) 4 (d) 0
56. Who got Nobel Prize for artificial synthesis of RNA?
(a) Khorana (b) Kornberg
(c) Ochoa (d) Nirenberg
57. Which is the 'Vital dye' for Golgi complex?
(a) Janus-green (b) Neutral red
(c) Fast green (d) Methylene blue
58. 'Druses' are deposits of:
(a) Calcium oxalate (b) CaCO$_3$
(c) Silica (d) All of these
59. Octamer of 4 types of histones wrapped by DNA thread is called:
(a) Centrosome (b) Synaptonemal complex
(c) Microsome (d) Nucleosome
60. A multinucleate cell in plants is called:
(a) Syncytium (b) Coenobium
(c) Coenocyte (d) Thallus
61. Ribosome is attached to ER by:
(a) Smaller unit (b) Larger unit
(c) Either of two units (d) By both units
62. Resin duct of *Pinus* is a:
(a) Schizogenous cavity (b) Lysigenous cavity
(c) Schizolysigenous cavity (d) None of these

63. Polytene chromosomes are found in:
(a) Oocyte nuclei of *Drosophila*
(b) Salivary gland cells of *Drosophila*
(c) Spermatocyte nuclei of *Drosophila*
(d) None of the above

64. Key-Lock theory of enzyme action was given by:
(a) Michaelis (b) Menton
(c) Summner (d) Fischer

65. Stages of appearance and disappearance of Synaptonemal complex is:
(a) Zygotene and pachytene
(b) Pachytene and diplotene
(c) Zygotene and diplotene
(d) Pachytene and diakinesis

66. Formation of embryo sac directly from megaspore mother cell in angiosperms is called:
(a) Apospory (b) Apogamy
(c) Diplospory (d) Agamospermy

67. Isobilateral pollen tetrads are common in:
(a) Monocots (b) Dicots
(c) Both (a) and (b) (d) None of these

68. Ubisch bodies are provided by:
(a) Pollens (b) Tapetum
(c) Middle layers (d) Endothecium

69. Red coloured 'Mace' which is used as condiment is obtained from nutmegs and is:
(a) Integument (b) Aril
(c) Caruncle (d) Perisperm

70. Normal type of embryo sac development is:
(a) *Oenothera* type (b) *Polygonum* type
(c) *Allium* type (d) *Pepromea* type

71. Single cotyledon of grass embryo is called:
(a) Coleoptile (b) Coleorhiza
(c) Scutellum (d) Aril

72. If the number of chromosomes in endosperm of an angiospermic plant is 36, what is the number of chromosomes in integuments?
(a) 36 (b) 18
(c) 24 (d) 12

73. How many meiotic divisions are necessary to produce 200 grains in wheat?
(a) 125 (b) 250
(c) 400 (d) 500

74. Polyembryony is more frequent in:
(a) Angiosperms (b) Gymnosperms
(c) Pteridophytes (d) None of these

75. Xenia is effect of pollens on:
(a) Flower (b) Endosperm
(c) Nucellus (d) Root

76. Maximum percentage of carbohydrates is in:
(a) Wheat (b) Rice
(c) Maize (d) Barley

77. Chocholate is prepared from:
(a) Seeds of *Coffea* (b) Seeds of *Theobroma*
(c) Seeds of *Erythroxylon* (d) None of these

78. Pyrethrum (Insecticide) is obtained from:
(a) *Urginea* bulb (b) *Cinchona*
(c) *Chrysanthemum* (d) *Derris*

79. A plant is having pentangular stem and also leaf opposed branched tendrils, it belongs to family:
(a) Malvaceae (b) Papilionaceae
(c) Cucurbitaceae (d) None of these.

80. Leaf apex tendrils are present in:
(a) *Clematis* (b) *Lathyrus*
(c) *Smilax* (d) *Gloriosa*

81. A type of inflorescence in which pedicillate flowers are arranged acropetally and pedicels are of unequal length so that they reach upto the same height is:
(a) Raceme (b) Cyme
(c) Corymb (d) Panicle

82. The placentation in compositae is:
(a) Marginal (b) Parietal
(c) Axile (d) Basal

83. The edible part in orange is:
(a) Unicellular placental hair
(b) Unicellular endocarpic hair
(c) Multicellular endocarpic hair
(d) Multicellular placental hair

84. 'Censer mechanism' of fruit dispersal is in:
(a) *Papaver* (b) *Argemone*
(c) *Aristolochia* (d) All of these

85. Blue-green algae, which live endophytically in protozoans are called:
(a) Cyanophages (b) Cyanobacteria
(c) Plasmids (d) Cyanallae

86. Which is agarophyte?
(a) *Gelidium* (b) *Gracillaria*
(c) *Gigartima* (d) All of these

87. *Spirogyra* occurs in:
(a) Running salt water (b) Running fresh water
(c) Stagnant salt water (d) Stagnant fresh water

88. 'LSD' is obtained from:
(a) *Clavatia* (b) *Claviceps*
(c) *Amanita* (d) *Trichoderma*

89. 'Perfect stage' of fungus means:
(a) When fungi is perfectly healthy
(b) When it reproduces asexually
(c) When it reproduces sexually
(d) None of the above

90. A broad spectrum antibiotic produced by lichens is:
(a) Bactrin (b) Griseofulvin
(c) Usnic acid (d) Chlorellin

91. Binary fission in bacteria occurs after every:
(a) 1 hour (b) 2 hours
(c) 20 minutes (d) 2 minutes

92. Viruses are nucleoproteins was shown by:
(a) Stanley (b) Bawden and Pieri
(c) d'Herelle (d) Ivanowski

93. A worker who is studying the gross internal structure of plant organs after cutting the sections, is working on:

(a) Morphology (b) Anatomy
(c) Histology (d) Morphogenesis

94. 'Histogen concept' for shoot apex organization was given by:
(a) Nageli (b) Hanstein
(c) Schmidt (d) Grew

95. Most primitive land plants are:
(a) Algae (b) Fungi
(c) Bryophytes (d) Pteridophytes

96. Fern prothallus normally is:
(a) Haploid (b) Diploid
(c) Triploid (d) Tetraploid

97. The antherozoids in *Cycas* are:
(a) Small, uniciliate, ovoid
(b) Small, lens-shaped and multiciliate
(c) Large, top-shaped, multiciliate
(d) large, top-shaped, biciliated

98. *Hydrilla* and *Vallisneria* are:
(a) Free floating hydrophytes
(b) Rooted emergent hydrophytes
(c) Rooted sub-merged hydrophytes
(d) Floating and anchored hydrophytes

99. *Nepenthes* is:
(a) Primary producer
(b) Primary consumer
(c) Primary producer and consumer
(d) Decomposer

100. The environment provided by wet leaf surface for microbial development is called:
(a) Rhizosphere (b) Rhizoplane
(c) Phyllosphere (d) Phylloplane

ANSWERS

1—d	2—c	3—b	4—a	5—c	6—c	7—b	8—c	9—c	10—b	11—b	12—b
13—b	14—b	15—c	16—c	17—b	18—c	19—c	20—c	21—b	22—d	23—c	24—a
25—d	26—a	27—c	28—b	29—c	30—c	31—b	32—c	33—c	34—c	35—c	36—d
37—d	38—c	39—d	40—d	41—c	42—d	43—d	44—b	45—b	46—b	47—c	48—c
49—c	50—c	51—c	52—d	53—d	54—d	55—b	56—c	57—d	58—a	59—d	60—c
61—b	62—a	63—b	64—d	65—c	66—c	67—a	68—b	69—b	70—b	71—c	72—c
73—b	74—b	75—b	76—b	77—b	78—c	79—c	80—d	81—c	82—d	83—b	84—d
85—d	86—d	87—d	88—b	89—c	90—c	91—c	92—b	93—b	94—b	95—c	96—a
97—c	98—c	99—c	100—d								

SELF EVALUATION TEST–III

1. The peripheral and central microtubules are arranged in which pattern in flagellum or cilium of eukaryotes?
   (a) 9 + 2 pattern (b) 2 + 9 pattern
   (c) 7 + 2 pattern (d) 8 + 2 pattern
2. In replication of DNA, the helix is uncoiled or unwounded by the enzyme:
   (a) DNA polymerase (b) DNA ligase
   (c) Helicase (d) Transacetylase
3. Virion is:
   (a) A completely assembled virus outside host
   (b) Viral protein coat
   (c) Viral nucleic acid
   (d) Viral ribosome
4. In C_4 plants, CO_2 fixation occurs in:
   (a) Bundle sheath (b) Mesophyll cells
   (c) Chlorenchymatous cells (d) Both (a) and (b)
5. F^+ factor playing significant role in conjugation of bacteria is actually:
   (a) Viroid (b) Virion
   (c) Plasmid (d) Lysogenic phage
6. 'Turn pipe' mechanism of pollination occurs in:
   (a) *Yucca* (b) *Ophrys*
   (c) *Salvia* (d) *Aristolochia*
7. The portion of embryo between cotyledons and radicle is called:
   (a) Epicotyl (b) Hypocotyl
   (c) Root apex (d) None of these
8. A plant widely used in nucleo-cytoplasmic studies is:
   (a) *Neurospora* (b) *Acetabularia*
   (c) *Aulosira* (d) *Nostoc*
9. Tyloses are found in:
   (a) Secondary phloem (b) Secondary xylem
   (c) Phellem (d) Phellogen
10. In *Spirogyra*, lateral conjugation occurs in:
    (a) Homothallic species (b) Heterothallic species
    (c) Both (a) and (b) (d) None of these
11. Source of antibiotic chloramphenicol is:
    (a) Lichen (b) Alga
    (c) *Penicillium* (d) *Streptomyces*
12. When entire sporangium develops from a single superficial cell of fern sporophyll, it is called:
    (a) Leptosporangiate development
    (b) Eusporangiate development
    (c) Monosporangiate development
    (d) None of the above
13. Phyllode is modified:
    (a) Leaf (b) Leaf petiole
    (c) Stem (d) Root
14. Petiolar tendrils are present in:
    (a) *Passiflora* (b) *Antigonon*
    (c) *Clematis* (d) *Bauhinia*
15. Which of the following elements are needed for chlorophyll formation?
    (a) Mg and Fe (b) S and P
    (c) Cu and Cl (d) Ca and Mg
16. What will happen in a long day plant (LDP) below critical day length?
    (a) It will remain in its vegetative phase
    (b) It will remain in flowering phase
    (c) Seedless fruits will be produced
    (d) Nothing will happen
17. Which of the following will be always in photochemical smog?
    (a) CH_4 (b) O_3
    (c) P (d) S
18. Totality of hereditary material present outside nucleus is called:
    (a) Genome (b) Plasmon
    (c) Both (a) and (b) (d) Microsome
19. Reaction centre of PS–II is:
    (a) P 700 (b) P 890
    (c) P 680 (d) None of these
20. Chlorophyll -a is different from chlorophyll -b in:
    (a) CHO group is present at C–3
    (b) CH_3 group is present at C–3
    (c) C═O group is present at C–3
    (d) OH group is present at C–3
21. Bacteria and cyanobacteria are included in a separate kingdom by Whittacker, called:
    (a) Protista (b) Monera
    (c) Plantae (d) Mycota
22. Niche is:
    (a) Habitat of a species
    (b) Specific habitat of a species for its operation
    (c) Functional role of a species
    (d) None of the above
23. Parallel term for ecosystem is:
    (a) Biocoenosis (b) Biogeocoenosis
    (c) Holocoen (d) Both (b) and (c)
24. Pinocytosis does not occur in :
    (a) Bacteria (b) Cyanobacteria
    (c) Both (a) and (b) (d) None of these
25. Mutagenic property of X-rays was first reported in maize and barley by:
    (a) H.J. Muller (b) L.J. Stadler
    (c) C. Auerbach (d) Camerarius
26. Fruit of *Ficus benghalensis* is:
    (a) Drupe (b) Sorosis
    (c) Syconus (d) Etaerio
27. Which of the following is positively photoblastic seed?
    (a) *Rumex* (b) *Spinacea*
    (c) *Lactuca* (d) *Lycopersicum*

28. 'Pusa Lerma' is a variety of:
(a) Maize (b) Rice
(c) Wheat (d) Sugar cane

29. Which of the following is basic amino acid?
(a) Glutamic acid (b) Glycine
(c) Valine (d) Lysine

30. Amino acid sequence of insulin was first given by:
(a) Kornberg (b) Jacob and Monod
(c) Khorana (d) Sanger

31. Which of the following is bacteria caused disease?
(a) Polio (b) Kawasaki disease
(c) Measles (d) Leprosy

32. In a plasmolysed cell, space between cell wall and cell membrane is occupied by:
(a) Hypotonic solution (b) Hypertonic solution
(c) Isotonic solution (d) Water

33. In germinating groundnut (*Arachis hypogea*) seeds, R.Q. is:
(a) 1 (b) Less than 1
(c) More than 1 (d) Zero

34. Which pigment is associated with red far red reversible photoreaction?
(a) Chlorophyll (b) Cytochrome
(c) Phytochrome (d) Anthocyanin

35. Which of the following radioactive fallout accumulates in bones?
(a) S^{35} (b) P^{32}
(c) Sr^{90} (d) Cs^{137}

36. Senescence of detached leaves can be delayed by:
(a) IAA (b) GA
(c) Cytokinins (d) ABA

37. Bacterial cell with flagella all over its surface, is called:
(a) Amphitrichous (b) Lophotrichous
(c) Cephalotrichous (d) Peritrichous

38. Double fertilization is a characteristic feature of:
(a) Gymnosperms (b) Angiosperms
(c) Pteridophytes (d) Thallophytes

39. Most sensitive to air pollution are:
(a) Lichens (b) Slime moulds
(c) Bacteria (d) PPLO's

40. Toad stools, puff balls and bracket fungi are included in which class of fungi?
(a) Phycomycetes (b) Ascomycetes
(c) Basidiomycetes (d) Deuteromycetes

41. Under influence of DNA polymerase enzyme, new DNA stand is formed in which direction?
(a) 3′ – 5′ direction (b) 5′–3′ direction
(c) In both these directions (d) None of these

42. Pure culture technique of bacteria was developed by:
(a) Lister (b) Leeuwenhoek
(c) Pasteur (d) Robert Koch

43. *Raphanobrassica* is an example of:
(a) Autopolyploidy (b) Allopolyploidy
(c) Heteroploidy (d) Trisomy

44. Terminalization process in meiosis starts in:
(a) Zygotene (b) Pachytene
(c) Diplotene (d) Diakinesis

45. Two gene pairs controlling human skin colour, was observed by:
(a) Nilsson-Ehle (b) Davenport
(c) T. H. Morgan (d) Jacob and Monod

46. 'Reindeer moss' is:
(a) *Chondrus crispus* (b) *Parmelia*
(c) *Cladonia rengiferina* (d) None of these

47. Mineral salt absorption in plants occurs in which form?
(a) Gaseous form (b) Ionic form
(c) Solid form (d) All of these

48. Excess of parental combinations as compared to non-parental combinations in offsprings, is called:
(a) Codominance (b) Linkage
(c) Crossing over (d) Polygenic inheritance

49. Reserpine alkaloid is obtained from which part of *Rauwolfia serpentina*?
(a) Root (b) Stem
(c) Leaf (d) Flower

50. Both heterophyllous and heterosporous conditions occur in:
(a) *Dryopteris* (b) *Adiantum*
(c) *Selaginella* (d) *Pteris*

51. 5-bromouracil replaces .... in transitions:
(a) Adenine (b) Guanine
(c) Cytosine (d) Thymine

52. Snapdragon is an example of:
(a) Blending inheritance
(b) Interaction of complementary factors
(c) Supplementary factors
(d) Lethal factors

53. Which of the following is obligate parasite?
(a) *Salmonella* (b) *Puccinia*
(c) *Ustilago* (d) HIV

54. When two gene pairs are involved in pericarp colour of wheat, then what is expected F_2 phenotypic ratio?
(a) 9 : 6 : 1 (b) 1 : 4 : 6 : 4 : 1
(c) 9 : 7 (d) None of these

55. Buttress roots are present in:
(a) *Pandanus* (Screw pine) (b) *Terminalia* (Arjun)
(c) *Tinospora* (d) Both (a) and (b)

56. Concept of heterosis or hybrid vigour was first given by:
(a) Morgan, T.H. (b) Camerarius
(c) Fairchild (d) Shull, G.H.

57. Hornwort is common name of:
(a) *Riccia* (b) *Marchantia*
(c) *Anthoceros* (d) *Funaria*

58. Nullisomic is:
(a) $2n - 1$ (b) $2n + 1$
(c) $2n + 2$ (d) $2n - 2$

59. Which is not a biotic component of ecosystem?
(a) Herbivores
(b) Phytoplanktons and zooplanktons

(c) Light
(d) Carnivores

60. Causal organism of late blight of potato is:
(a) *Albugo candida* (b) *Pythium debaryanum*
(c) *Phytophthora infestans* (d) *Colletotrichum falcatum*

61. Probable structure for N_2-fixation in cyanobacteria is:
(a) Heterocyst (b) Akinete
(c) Trichome (d) Chromatophore

62. The branch concerned with forests and utilization of forest products, is:
(a) Agrostology (b) Horticulture
(c) Silviculture (d) Sericulture

63. Enzyme used for cutting DNA at specific site in genetic engineering, is:
(a) Polynucleotide ligase
(b) DNA polymerase
(c) Restriction endonuclease
(d) Helicase

64. Energy stored at consumers level is called:
(a) Gross primary productivity
(b) Net primary productivity
(c) Secondary productivity
(d) Primary productivity

65. Which is true for Rous sarcoma virus?
(a) DNA → RNA → Proteins
(b) RNA → DNA → RNA → Proteins
(c) RNA → RNA → DNA → Proteins
(d) RNA → RNA → Proteins

66. Van Mahotsava was started by K.M. Munshi in:
(a) 1962 (b) 1955
(c) 1950 (d) 1958

67. Tapetum layer of anther provides:
(a) Nutrition
(b) Nutrition + Pollen kitt substances
(c) Nutrition + Callase enzyme + Sporopollenin
(d) Nutrition + Pollen kitt substances + Callase + Sporopollenin

68. 'Acid rain' is caused by excess of:
(a) $SO_2 + NO_2$ (b) $O_3 + CO_2$
(c) $CO + CO_2$ (d) $CO + SO_2$

69. The primary role of NAD in Kreb's cycle is:
(a) Acts as an oxygen donor
(b) Acts as an oxygen acceptor
(c) Acts as hydrogen ion and electron acceptor
(d) Acts as an electron donor

70. Pycnoxylic wood is:
(a) Soft and loose
(b) Compact and hard
(c) Wood with many annual rings
(d) Wood derived from phellogen

71. Which of the following angiospermic plant is having diploid endosperm?
(a) *Oenothera* (b) *Polygonum*
(c) *Pepromea* (d) *Fritillaria*

72. Ascending imbricate aestivation of petals is characteristic feature of:
(a) Papilionaceae (b) Caesalpiniaceae
(c) Mimosaceae (d) Solanaceae

73. Phycobilin pigments are characteristic of:
(a) Cyanobacteria (b) Rhodophyceae
(c) Both (a) and (b) (d) None of these

74. Exchange of chromosomal segments between non-homologous chromosomes is called :
(a) Crossing over (b) Translocation
(c) Inversion (d) Duplication

75. Pollen kitt is connected with:
(a) Insect pollination (b) Wind pollination
(c) Water pollination (d) Animal pollination

76. In *Cycas* and *Pinus* leaves, which tissue is concerned with lateral conduction of food?
(a) Transfer cells (b) Vascular bundle
(c) Transfusion tissue (d) Lateral veins

77. Which is associated with production of androgenic haploids?
(a) Embryo culture (b) Protoplast culture
(c) Endosperm culture (d) Anther culture

78. Indian botanist concerned with metabolism of cyanophyceae was:
(a) Desikachary (b) Iyenger
(c) R.N. Singh (d) R. Mishra

79. If $2n = 14$ in *Pinus*, what is the chromosome number in its primary endosperm nucleus?
(a) 42 (b) 28
(c) 14 (d) 7

80. A mosquito repellant called 'Pyrethrum oil' is obtained from:
(a) *Chrysanthemum cinerarifolium*
(b) *Derris* sps.
(c) *Lonchocarpus* sps.
(d) *Carthamus tinctorius*

81. Coleoptile in grass embryo helps in:
(a) Protection of plumule
(b) Protection of radicle
(c) Forms radicle and plumule
(d) Protection of cotyledon

82. Dichogamy in plants is a contrivance (adaptation) for:
(a) Autogamy (b) Allogamy
(c) Chasmogamy (d) Cleistogamy

83. Which is characteristic of family Liliaceae?
(a) Bicarpellary ovary (b) Versatile anthers
(c) Sessile leaves (d) Petaloid perianth

84. In a cytochrome molecule, which atom is actually responsible for accepting and releasing electrons?
(a) Ca (b) Fe
(c) Zn (d) C

85. Which family is characterized by tricarpellary, unilocular, inferior ovary with parietal placentation?
(a) Solanaceae. (b) Cucurbitaceae
(c) Liliaceae (d) Ranunculaceae

86. Phellem shows deposition of which of the following?
    (a) Cellulose (b) Lignin
    (c) Suberin (d) Silica
87. Guttation phenomenon is menifestation of:
    (a) Diffusion (b) Osmotic pressure
    (c) Suction pressure (d) Root pressure
88. Multiple epidermis with sunken stomata and stomatal hairs are characteristic of:
    (a) *Nerium* (b) *Mangifera*
    (c) *Pinus* (d) *Nymphaea*
89. 'Norin gene' was introduced for improvement of:
    (a) Wheat (b) Maize
    (c) Rice (d) Potato
90. Which plant is not economically important?
    (a) *Vigna sinensis* (b) *Lathyrus sativus*
    (c) *Phaseolus aconitifolius* (d) *Anacardium occidentale*
91. Seeds of a plant are adulterated with mustard seeds and the mixed oil cause a disease called dropsy. The plant is:
    (a) *Argemone mexicana* (b) *Calotropis procera*
    (c) *Lathyrus sativus* (d) None of these
92. Which of the following are non-vascular cryptogams?
    (a) Algae and fungi (thallophyta)
    (b) Thallophytes and bryophytes
    (c) Thallophytes, bryophytes and pteridophytes
    (d) Only pteridophytes
93. Number of linkage groups in *E. coli* bacterium is:
    (a) One (b) Two
    (c) Three (d) Eight
94. Independent gametophytic generation is present in:
    (a) Thallophytes
    (b) Thallophytes and bryophytes
    (c) Bryophytes and pteridophytes
    (d) None of the above
95. Main source of sugar in Europe is:
    (a) Sugar cane (b) Beet root
    (c) Toddy palm (d) Both (a) and (c)
96. Functional unit of DNA is called:
    (a) Gene (b) Cistron
    (c) Recon (d) Muton
97. Eutrophication in lakes leads to:
    (a) Increase in BOD (b) Decrease in BOD
    (c) No change in BOD (d) All of these
98. Which of the following bacteria is used to form artificial snow at winter holiday resorts?
    (a) *Bacillus thuringenesis* (b) *Bacillus polymyxa*
    (c) *Pseudomonas syringae* (d) *Propionibacteria*
99. Chemical produced by plant tissue cultures used as a dye in silk industry and also in treatment of burns, is:
    (a) Shikonin (b) Pyrethrin
    (c) Digoxin (d) Menthol
100. First pesticide used throughout the world on large scale was:
    (a) DDT (b) Aldrin
    (c) 2, 4-D (d) Malathion

ANSWERS

1—a	2—c	3—a	4—d	5—c	6—c	7—b	8—b	9—b	10—a	11—d	12—a
13—b	14—c	15—a	16—a	17—b	18—b	19—c	20—b	21—b	22—b	23—d	24—c
25—b	26—c	27—c	28—c	29—d	30—d	31—d	32—b	33—b	24—c	35—c	36—c
37—d	38—b	39—a	40—c	41—b	42—d	43—b	44—c	45—b	46—c	47—b	48—b
49—a	50—c	51—d	52—a, d	53—d	54—b	55—b	56—d	57—c	58—d	59—c	60—c
61—a	62—c	63—c	64—c	65—b	66—c	67—d	68—a	69—c	70—b	71—a	72—b
73—c	74—b	75—a	76—c	77—d	78—c	79—d	80—a	81—a	82—b	83—d	84—b
85—b	86—c	87—d	88—a	89—a	90—b	91—a	92—b	93—a	94—b	95—b	96—b
97—a	98—c	99—a	100—a								

SELF EVALUATION TEST–IV

1. The pioneer Indian worker who reported the role of blue green algae in nitrogen fixation, is:
(a) P.K. De (b) R.N. Singh
(c) Desikachary (d) M.O.P. Iyenger

2. Gas forming and food poisoning bacillus form of bacterium is:
(a) *E. coli* (b) *Clostridium*
(c) *Salmonella* (d) *Diplococcus*

3. *Nostoc* filament without mucilaginous sheath is called:
(a) Filament (b) Trichome
(c) Pseudomycelium (d) Hyphae

4. Meiosis in *Ulothrix* occurs in:
(a) Somatic cell (b) Holdfast
(c) Zygospore (d) Gamete

5. Infoldings of cell membrane in bacterial cell are known as:
(a) Glyoxysomes (b) Microsomes
(c) Mesosomes (d) Episomes

6. Which of the following are characterized by presence of genophore or nucleoid?
(a) Only bacterial cells
(b) Only higher plant cells
(c) Bacterial and cyanobacterial cells
(d) Only cyanobacterial cells

7. Fungus used in cheese flavouring is:
(a) *Aspergillus niger* (b) *Penicillium camembertii*
(c) *Penicillium roquefortii* (d) Both (b) and (c)

8. Sexuality in bacteria was first reported by:
(a) Zinder (b) Lederberg
(c) Tatum (d) Lederberg and Tatum

9. Which of the following is not present in cell wall of bacteria?
(a) NAG (b) NAM
(c) Lipids (d) Cellulose

10. Semiparasitic relationship between algal and fungal parteners in lichens is nowadays known as:
(a) Mutualism (b) Helotism
(c) Epiphytism (d) Consortium

11. Naked seeds are characteristic of:
(a) *Selaginella* (b) *Cycas*
(c) *Pinus* (d) Both (b) and (c)

12. In moss *(Funaria)*, stomata are present in:
(a) Foot region
(b) Theca region of capsule
(c) Apophysis region of capsule
(d) Operculum region of capsule

13. Ramenta are characteristic of:
(a) *Marchantia* (b) *Funaria*
(c) *Dryopteris* (d) None of these

14. Embryo of *Pinus* shows:
(a) Monocotyly (b) Dicotyly
(c) Polycotyly (d) Acotyly

15. Multiflagellate antherozoids are found in:
(a) *Riccia* (b) *Pinus*
(c) *Dryopteris* (d) *Funaria*

16. Fasciculated roots are present in:
(a) *Raphanus* (b) *Asparagus*
(c) *Vanda* (d) None of these

17. Single seeded winged fruit is called:
(a) Achene (b) Cypsella
(c) Samara (d) Caryopsis

18. Gynobasic style is characteristic feature of:
(a) Malvaceae (b) Lamiaceae
(c) Ranunculaceae (d) Brassicaceae

19. Etaerio of achenes is fruit of:
(a) Lotus (b) Radish
(c) Hiptage (d) Banyan

20. Which of the following has endogenous origin?
(a) Branch (b) Leaf
(c) Flowers (d) Lateral roots

21. A type of inflorescence where different flowers arise from different points but due to different lengths of pedicels reach upto the same height, is known as:
(a) Raceme (b) Sorosis
(c) Corymb (d) Umbel

22. Which of the following is floral formula of disc-floret of *Helianthus*?
(a) $\oplus$ ⚥ $K_{(\text{pappus})}\ \overset{\frown}{C_{(5)}\ A_{(5)}}\ \overline{G_{(2)}}$
(b) $\oplus$ ♀ $K_{(\text{pappus})}\ \overset{\frown}{C_5\ A_5}\ \underline{G_{(2)}}$
(c) + ♀ $K_5\ C_5\ A_0\ \underline{G_{(2)}}$
(d) None of the above

23. Inflorescence axis is called:
(a) Rachis (b) Pedicel
(c) Petiole (d) Peduncle

24. Acicular leaves are present in:
(a) *Allium* (b) *Solanum*
(c) *Brassica* (d) *Helianthus*

25. Large coloured structures in *Bougainvillea* are infact:
(a) Sepals (b) Petals
(c) Bracts (d) Stamens

26. Triploid tissue in angiosperms is:
(a) Nucellus (b) Endosperm
(c) Endothelium (d) Tapetum

27. A very close symbiotic relation between a flower and moth *Pronuba* (pollinating agent) occurs in:
(a) *Salvia* (b) *Yucca*
(c) *Ophrys* (d) *Asparagus*

28. Which part of reproductive structure has property of producing both enzymes and hormones?
(a) Endothecium (b) Tapetum
(c) Middle layers (d) Archesporium

29. Cheiropterophily occurs in:
(a) *Yucca*
(b) *Nicotiana tabacum*
(c) *Callistemon lanceolatum*
(d) *Adansonia digitata*

30. Caruncle in castor is derived from:
(a) Placenta (b) Perisperm
(c) Outer integument (d) Inner integument

31. Active cell division in a plant will be observed in:
(a) Cortex (b) Medulla
(c) Shoot apex (d) All of these

32. Distinction between a monocot and dicot plant can be made on the basis of:
(a) Phyllotaxy (b) Vernation
(c) Venation (d) Aestivation

33. Xerophytic trees show:
(a) Well defined annual-rings
(b) No distinct annual rings
(c) Alternate rings of xylem and sclerenchyma
(d) None of the above

34. Source of lemon grass oil is:
(a) *Carthamus tinctorius* (b) *Cymbopogon nardus*
(c) *Cymbopogon flexuosus* (d) *Sesamum indicum*

35. Which of the following is new world cotton?
(a) *Gossypium herbaceum* (b) *G. arboreum*
(c) *G. barbadense* (d) None of these

36. Screw pine is:
(a) *Anacardium occidentale*
(b) *Pinus merkussi*
(c) *Pandanus odoratissimus*
(d) *Cyamopsis tetragonoloba*

37. Turmeric powder is obtained from which part of turmeric plant?
(a) Seeds (b) Rhizome
(c) Root (d) Fruit

38. Monosomic condition (XO) in human beings is known as:
(a) Down's syndrome (b) Turner's syndrome
(c) Klinfelter's syndrome (d) None of these

39. 'Lac operon' is transcribed when:
(a) Lactose is absent in the cell
(b) Lactose is present in the cell
(c) Galactose is present in the cell
(d) Repressor molecules are available in the cell

40. A gene is possessed by rous sorcoma virus for a particular enzyme, which uses RNA of virus for synthesis of DNA. What is that enzyme?
(a) RNA polymerase (b) RNA transcriptase
(c) Reverse transcriptase (d) Endonuclease

41. Fragmented DNA molecule is having sticky ends, made of:
(a) Potassium ions (b) Calcium ions
(c) Unpaired N-bases (d) Methyl group

42. Initiator codon AUG starts translation. It codes for:
(a) Phenyl alanine (b) Methionine
(c) Valine (d) None of these

43. The first human hormone produced as a result of recombinant DNA technology is:
(a) Testosterone (b) Insulin
(c) Thyroxin (d) None of these

44. 'Allelomorphs' are actually:
(a) Pairs of dominants
(b) Pairs of recessives
(c) Pairs of contrasting characters
(d) Pairs of non-allelic characters

45. Holandric genes are those:
(a) Present on autosomes
(b) Present on X-chromosomes
(c) Present on Y-chromosomes
(d) None of the above

46. Which structure in prokaryotes is responsible for transfer of gene from one organism to another?
(a) Plasmid (b) Ribosome
(c) Mesosome (d) Volutin granules

47. A gene is having:
(a) Only single triplet codon
(b) Part of a strand of DNA
(c) Many triplet codons
(d) Three triplet codons

48. Barbara Mc Clintock (Lady Mendel) got Nobel Prize for discovery of jumping genes. She mainly worked on:
(a) Wheat (b) Maize
(c) *Antirrhinum* (d) *Drosophila*

49. Inheritance of cytoplasmic male sterility in maize is:
(a) Maternal (b) Paternal
(c) Both (a) and (b) (d) None of these

50. Haploid set of chromosome is known as:
(a) Gamete (b) Genome
(c) Plasmon (d) Episome

51. Pioneers to colonize a bare rock are:
(a) Lichens (b) Mosses
(c) Herbs (d) Shrubs

52. Most of the food-chains are having:
(a) 1–2 species (b) 8–10 species
(c) 3–4 species (d) More than 10 species

53. Main factor behind water pollution is:
(a) Automobiles (b) Insecticides and herbicides
(c) Industrial wastes (d) Smoke

54. Which of the following is environmental planning organization?
(a) NEERI (b) CDRI
(c) CSIR (d) MAB

55. A fibre of plant origin which is longest, toughest, strongest and having durability is:
(a) *Bombax* (b) *Agave*
(c) *Linum* (d) *Boehmeria*

56. Muscular distrophy (lathyrism) is caused by eating *Lathyrus sativus*. This is due to presence of:
(a) Cucurbitacin (b) β-oxalyl amino alanine
(c) Allyl sulphide (d) Transcinnamic acid

57. Pop maize is:
(a) *Zea mays* var. *everta* (b) *Z. mays* var. *tunicata*
(c) *Z. mays* var. *saccharata* (d) None of these

58. Source of 'Truth drug' of world war-II is:
(a) *Rauvolfia serpentina* (b) *Papaver somniferum*
(c) *Atropa belladona* (d) None of these

59. Which of the following variety is not the result of mutation?
(a) Aruna var. in castor
(b) Remei var. in rice
(c) Todd's mitcham var. in peppermint
(d) None of the above

60. Origin of cultivated plants was extensively studied by:
(a) Linnaeus (b) de Candolle
(c) Vavilov (d) B.P. Pal

61. Quantasome (photosynthetic unit) is assembly of:
(a) 50 chlorophyll molecules
(b) 120 chlorophyll molecules
(c) 230 chlorophyll molecules
(d) 430 chlorophyll molecules

62. Agricultural substances 'Devine' and 'Collego' are:
(a) Bioherbicides (b) Biofertilizers
(c) Insect hormones (d) None of these

63. Mexican wheat varieties are:
(a) Haploid (b) Diploid
(c) Tetraploid (d) Hexaploid

64. Source of malt is:
(a) Wheat (b) Rice
(c) Barley (d) Maize

65. The plants used for production of ethanol are known as:
(a) Energy crops (b) Biocrops
(c) Transgenic plants (d) Cryogenic crops

66. In Vietnam war, 'Agent orange' used by Americans is:
(a) NAA (b) 2, 4, 5–T
(c) IAA (d) IBA

67. The function of synaptonemal complex (SC) is:
(a) Pairing of non-homologous chromosomes
(b) Repulsion of homologous chromosomes
(c) Pairing of homologous chromosomes
(d) Increase in number of chromonemata (polyteny)

68. Cellular structure which always disappears during mitotic cell division is:
(a) Cell membrane (b) Nucleolus
(c) Chloroplast (d) None of these

69. Which of the following is 'energy currency' of the cell?
(a) ADP (b) $NADH_2$
(c) ATP (d) AMP

70. Chemically, spindle fibres are made of:
(a) Phospholipids (b) Glycolipids
(c) Proteins (d) Cellulose

71. One micron (μ) is equal to:
(a) One tenth of a millimetre
(b) One hundredth of a millimetre
(c) One thousandth of a millimetre
(d) One millimetre

72. Okazaki segments during DNA replication are united with the help of enzyme:
(a) Primase (b) Topoisomerase
(c) Polynucleotide ligase (d) DNA polymerase

73. Polytene chromosomes were discovered by:
(a) Kollar (b) Balbiani
(c) Emil Heitz (d) W. Flemming

74. The enormous diversity of protein molecules is mostly due to diversity of:
(a) Amino group on the amino acid
(b) Peptide bonds
(c) Sequences of amino acids within protein molecules
(d) 'R' group (side chain group) of amino acids

75. The portion of a plant cell between plasma membrane and nucleus is called:
(a) Lumen (b) Protoplasm
(c) Ergastoplasm (d) Cytoplasm

76. Proteins which are used outside the cells are synthesized:
(a) On free ribosomes (b) On bound ribosomes
(c) On smooth ER (d) On rough ER

77. Complex micromolecules like proteins and polysaccharides, etc., are broken down by:
(a) Lipochondrion (b) Lysosomes
(c) Mitochondria (d) Microsome

78. Water potential of a cell can be decreased by:
(a) Addition of solvent (water)
(b) Addition of solutes
(c) Increasing the temperature
(d) None of the above

79. Under water stress conditions, the hormone controlling closing of stomata is:
(a) GA_3 (b) ABA
(c) IAA (d) Cytokinins

80. Most rapid rate of transpiration will be when:
(a) Fully saturated atmosphere with water vapours
(b) Availability of water is in excess
(c) Air is still and calm
(d) Dry atmospheric conditions

81. Which enzyme is required by nitrogen fixing bacteria?
(a) Nitrogenase (b) Reductive aminase
(c) Nitroxidase (d) Carboxylase

82. Storage of carbohydrates in plants is not done in the form of glucose, because it:
(a) Is sweet and attracts insects
(b) Is unstable
(c) Soluble in water and thus osmotic balance is disturbed
(d) All of the above

83. Crassulacean acid metabolism (CAM) occurs in:
(a) *Eucalyptus* (b) *Opuntia*
(c) *Poa* (d) *Gigartima*

84. Thylakoids are characteristic of plastids of:
(a) Cyanobacteria (b) Bacteria
(c) Higher plants (d) None of these

85. In cyclic photophosphorylation, the primary electron acceptor is:
(a) CoQ (b) FAD
(c) NADP (d) A protein having Fe and S

86. Total number of ATP molecules produced in EMP-pathway during aerobic conditions is:
(a) 2 (b) 4
(c) 8 (d) 24

87. Cholodny-Went theory is concerned with:
(a) Photoperiodism (b) Photorespiration
(c) Photophosphorylation (d) Phototropism

88. Biosphere is:
(a) All plants of world
(b) All plants of a specific region
(c) Area occupied by living organisms
(d) None of the above

89. Starch is a polymer of:
(a) Glucose (b) Fructose
(c) Sucrose (d) Lactose

90. Most abundant RNA of the cell is:
(a) m-RNA (b) t-RNA
(c) r-RNA (d) None of these

91. Vesicular arbuscular mycorrhiza (VAM) is characteristic of:
(a) Orchids (b) *Pinus*
(c) Oak (d) All of these

92. Free living or non-symbiotic nitrogen fixing bacteria is:
(a) *Azotobacter* (b) *Bacillus polymyxa*
(c) *Beijerinckia* (d) All of these

93. *Azospirillum lipoferum* bacterium is found to increase the yield of:
(a) Rice (b) Cotton
(c) Maize (d) Jawar

94. Advantage of energy plantation is:
(a) It is renewable
(b) Does not require any specific technology
(c) Ecologically safe
(d) All of the above

95. Centre of origin of rubber is:
(a) Brazil (b) Peru
(c) Ethiopia (d) Central Asia

96. Resistance to which disease in potato has been derived from *Solanum demissum*?
(a) Potato virus X (b) Potato virus Y
(c) Potato leaf roll virus (d) Late blight of Potato

97. A widely cultivated rice variety which has solved food problem in Asia and has been developed by IRRI, Manila (Philippines) is:
(a) Dee-geo-woo-gen (b) IR-36
(c) Remei (d) Norin–10

98. Latex of which plant is a substitute for para rubber?
(a) *Leuçaena* (b) *Parthenium argentatum*
(c) *Azadirachta indica* (d) *Simmondsia chinensis*

99. Which of the following pesticides are derivatives of urea and are used as weedicides?
(a) Pyrethoids (b) Carbamates
(c) Triazines (d) Organochlorines

100. Hybridoma cells produce:
(a) Monoclonal antibodies (b) Artificial snow
(c) Antibiotics (d) Shikonin

ANSWERS

1—a	2—b	3—b	4—c	5—c	6—c	7—d	8—b	9—d	10—b	11—d	12—c
13—c	14—c	15—c	16—b	17—c	18—b	19—a	20—d	21—c	22—a	23—d	24—a
25—c	26—b	27—b	28—b	29—d	30—c	31—c	32—c	33—b	34—b	35—c	36—c
37—b	38—b	39—b	40—c	41—c	42—b	43—b	44—c	45—c	46—a	47—c	48—b
49—a	50—b	51—a	52—c	53—c	54—a	55—d	56—b	57—a	58—c	59—d	60—c
61—c	62—a	63—d	64—c	65—a	66—b	67—c	68—b	69—c	70—c	71—c	72—c
73—b	74—c	75—d	76—a	77—b	78—b	79—b	80—d	81—a	82—c	83—b	84—c
85—d	86—c	87—d	88—c	89—a	90—c	91—a	92—d	93—c	94—d	95—a	96—d
97—b	98—b	99—c	100—a								

SELF EVALUATION TEST–V

1. Non-living structure of cell is:
(a) Cell membrane [✓ (b) Cell wall]
(c) Nucleus (d) Cytoplasm

2. Cell organelle rich in catabolic enzymes is:
(a) Mitochondria (b) Lipochondrion
(c) Lysosome (d) ER

3. Who first proposed lamellar model of plasmalemma?
(a) Robertson (b) Davson and Danielli
(c) Singer and Nicolson (d) Robert Brown

4. Origin of ribosomes is from :
(a) ER (b) Chloroplast
(c) Nucleus (d) Nucleolus

5. Flagella of bacteria are made of:
(a) Tubulin protein (b) Actin protein
(c) Dyenein protein (d) Flagellin protein

6. Which organelle forms aster during cell division?
(a) Centrosome (b) Lysosome
(c) Mesosome (d) Microsome

7. Name 'polysome' is given to group of:
(a) Oxysomes (b) Microsomes
(c) Ribosomes (d) Sphaerosomes

8. Microtubules are characteristic of :
(a) Bacteria (b) Viruses
(c) Prokaryotes (d) Eukaryotes

9. Most diversified nature is shown by :
(a) Proteins (b) Nucleic acids
(c) Lipids (d) Carbohydrates

10. Which disease of potato is associated with famous Irish famine?
(a) Black wart disease (b) Early blight
(c) Late blight (d) Potato leaf roll

11. Which of the following is characterized with 'fairy ring' formation?
(a) *Rhizopus* (b) *Agaricus*
(c) *Ustilago* (d) *Puccinia*

12. Fungi imperfectii (Deuteromycetes) is characterized by lack of:
(a) Asexual reproduction (b) Sexual reproduction
(c) Spores (d) Well defined mycelium

13. Lichen used in poisoning wolves is:
(a) *Cetraria juniperina* (b) *Lecanora*
(c) *Cladonia rengiferina* (d) *Everina*

14. Edible red alga is:
(a) *Batrachospermum* (b) *Chlorella*
(c) *Porphyra* (d) *Nemalion*

15. Perennation in algae occurs by:
(a) Endospores, akinetes, zoospores
(b) Zoospores, aplanospores, hypnospores
(c) Aplanospores, hypnospores, zygospores
(d) All of the above

16. Source of kelp is:
(a) Green algae (b) Blue green algae
(c) Brown algae (d) Red algae

17. Water and mineral salt absorption in bryophytes take place by means of:
(a) Roots (b) Rhizinae
(c) Rhizoids (d) Adventitious roots

18. Moss is:
(a) Heterotrichous (b) Gregarious
(c) Both (a) and (b) (d) None of these

19. Chloroplasts are characteristic of spores of:
(a) *Saccharomyces* (b) *Dryopteris*
(c) *Funaria* (d) None of these

20. Which of the following is characterized by presence of archegonium?
(a) *Ulothrix* (b) *Rhizopus*
(c) *Spirogyra* (d) *Funaria*

21. Which is not present in moss sporophyte?
(a) Elaters (b) Foot
(c) Seta (d) Columella

22. Fern sporangium produces:
(a) 4–8 spores (b) 8–16 spores
(c) 32–64 spores (d) 128–256 spores

23. Rhizophore in *Selaginella* is:
(a) Root (b) Stem
(c) Leaf (d) Organ *sui-generis*

24. Wood is non-porous in:
(a) *Dalbergia* (b) *Shorea*
(c) *Mangifera* (d) *Pinus*

25. Resin canals present in gymnospermous stem are:
(a) Lysogenous cavities
(b) Schizogenous cavities
(c) Schizolysigenous cavities
(d) None of the above

26. Bordered pits are characteristic of:
(a) Pteridophytes (b) Gymnosperms
(c) Bryophytes (d) Thallophytes

27. 'Monkey's puzzle' plant is:
(a) *Araucaria* (b) *Adiantum*
(c) *Thuja* (d) *Anacardium*

28. Water is not necessary for sexual reproduction or act of fertilization in:
(a) *Ulothrix* (b) *Funaria*
(c) *Dryopteris* (d) *Cycas*

29. Pollination in *Cycas* occurs at:
(a) 1-celled stage (b) 2-celled stage
(c) 3-celled stage (d) 4-celled stage

30. System with a continuous influx of energy is called:
(a) Open system (b) Closed system
(c) Cybernete system (d) None of these

31. Which of the following is endoskeleton of cell?
(a) Cell wall (b) ER
(c) Cell membrane (d) Cytoplasm

32. In plasma membrane, carbohydrates are in the form of:
(a) Cellulose
(b) Starch
(c) Glucose
(d) Glycoproteins and glycolipids

33. How many nucleotides will be present in a fragment of DNA which contains 60 adenine and 60 cytosine bases?
(a) 60 (b) 120
(c) 240 (d) 480

34. In angiosperms, sperm is:
(a) A complete cell (b) Cell with a basal granule
(c) A naked nucleus (d) A naked cell

35. Leaves of which plant are used for making bidis?
(a) *Diospyros melanoxylon* (b) *Betula*
(c) *Fagus sylvatica* (d) *Quercus suber*

36. In palms, increase in girth of stem is due to:
(a) Activity of phellogen
(b) Activity of cambium ring
(c) Extension and elongation of ground tissue
(d) Fusion of persistent leaf bases with stem

37. 'Heroin' is obtained from a member of family:
(a) Apocynaceae (b) Brassicaceae
(c) Papaveraceae (d) Solanaceae

38. Etching and destruction of lenses of microscopes, cameras, telescopes, etc., in moist conditions is done by:
(a) Bacteria (b) PPLO
(c) Viruses (d) Fungi

39. Source of iodine is members of:
(a) Chlorophyceae (b) Phaeophyceae
(c) Rhodophyceae (d) Cyanophyceae

40. In event of infection of tobacco plant with TMV, what portion of TMV is injected into the plant?
(a) DNA (b) RNA
(c) Protein coat (d) Whole virus particle

41. Dimorphism of chloroplasts occurs in:
(a) Wheat (b) Rice
(c) Sugar cane (d) Tomato

42. In which sub-stage of prophase-I of meiosis chromosomes are maximally condensed?
(a) Leptotene (b) Pachytene
(c) Diplotene (d) Diakinesis

43. Tannins of plants are:
(a) Secretory substances of glands
(b) Reserve substances
(c) Excretory products
(d) Alkaloids

44. Secondary cortex in plants is the result of activity of:
(a) Cambium (b) Phellogen
(c) Phelloderm (d) Phellem

45. Barbara Mc Clintock, a Nobel Prize winner is associated with discovery of:
(a) Transposons
(b) Jumping genes
(c) Controlling elements in maize
(d) All of the above

46. Which oil is best for health of human beings?
(a) Mustard oil (b) Coconut oil
(c) Soybean oil (d) Sesame oil

47. In guttation:
(a) Pure water is lost
(b) Water with organic compounds is lost
(c) Water with mineral salts is lost
(d) Water with mineral salts and organic compounds is lost.

48. A gene which affects the character of another gene not located on similar locus of the homologous chromosome is:
(a) Duplicate gene (b) Complementary gene
(c) Supplementary gene (d) Epistatic gene

49. What is present in bacterial plasmid?
(a) RNA (b) DNA
(c) RNA + protein (d) DNA + protein

50. Which of the following statement is true?
(a) Etiolation and albinism are physiological
(b) Etiolation is genetic and albinism is physiological
(c) Etiolation is physiological and albinism is genetic
(d) Both are synonyms

51. Brown heart disease in cauliflower is the result of deficiency of:
(a) Fe (b) B
(c) Cu (d) P

52. The microscope used for study of viruses morphology is:
(a) Simple (b) Compound
(c) Polarizing (d) Electron

53. Although mitosis is the normal feature but abnormal and sudden mitosis in an organ results into formation of:
(a) Zygote (b) Gametes
(c) New organ (d) Cancers or galls

54. Disease resistance can be introduced in plants by:
(a) Hormone application
(b) High temperature treatment
(c) Colchicine treatment
(d) Crossing with wild species

55. Sex-linked genes were first discovered by:
(a) Muller (b) Morgan
(c) Castle (d) Mendel

56. The basic mechanism of transmission of hereditary variations is:
(a) Sexual reproduction (b) Asexual reproduction
(c) Polyploidy (d) None of these

57. *Rhizopus* and *Dryopteris* are similar in having:
(a) Hyphae (b) Columella
(c) Spores (d) Pinnule

58. 'Chlorophyll-d' is characteristic of:
(a) All green plants (b) All algae
(c) Rhodophyceae (d) Phaeophyceae

59. *Balanophora* is a:
(a) Total root parasite (b) Partial root parasite
(c) Total stem parasite (d) Partial stem parasite

60. Offset is present in:
(a) *Eichhornia* (b) *Passiflora*
(c) *Mentha* (d) *Colocasia*

61. Venation is present in which part of leaf?
(a) Mesopodium (b) Pulvinus
(c) Epipodium (d) Hypopodium

62. Female inflorescence in maize is:
(a) Spike (b) Spadix
(c) Tassel (d) Corymb

63. Internodal elongation between corolla and androecium is called:
(a) Anthophore (b) Gynophore
(c) Androgynophore (d) Androphore

64. The condition in which filaments are fused and anther lobes are free, is called:
(a) Adelphous (b) Syngenesious
(c) Gynandrous (d) Syncarpous

65. Translator mechanism of pollination occurs in:
(a) *Calotropis* (b) *Salvia*
(c) *Cestrum* (d) *Yucca*

66. Polysiphonous pollen grains are found in:
(a) *Althaea rosea* (b) *Malva*
(c) Both (a) and (b) (d) None of these

67. Amphisarca is characteristic fruit of:
(a) *Citrus reticulata* (b) *Aegle marmelos*
(c) *Datura innoxia* (d) *Psidium guajava*

68. In *Ruellia* (Acanthaceae), seed dispersal occurs by:
(a) Censer mechanism (b) Parachute mechanism
(c) Jaculator mechanism (d) Explosive mechanism

69. Plumed seeds (Hair all around seeds) are found in:
(a) *Ruellia* (b) *Calotropis*
(c) *Colutea* (d) *Tecoma*

70. Tapetal cells are characterized by:
(a) Mitotic division
(b) Meiotic division
(c) Endomitosis
(d) Endomitosis as well as endopolyploidy

71. Ubisch bodies of tapetal origin are associated with development of:
(a) Exine of pollen (b) Intine of poline
(c) Embryo sac (d) Integuments of ovule

72. Endothecium of anther wall has ploidy level:
(a) n (b) 2n
(c) 3n (d) 4n

73. Synonym of definitive nucleus in embryo sac is:
(a) Secondary nucleus (b) Vegetative nucleus
(c) Generative nucleus (d) None of these

74. Highest metabolic rate is present in:
(a) Xylem (b) Phloem
(c) Meristem (d) Parenchyma

75. Thick-walled lignified dead tissue is:
(a) Collenchyma (b) Chlorenchyma
(c) Sclerenchyma (d) Prosenchyma

76. Wood of commerce is:
(a) Early wood (b) Late wood
(c) Alburnum (d) Duramen

77. Interfascicular cambium is:
(a) Promeristem (b) Primary meristem
(c) Secondary meristem (d) None of these

78. First triplet codon discovered by Nirenberg and Matthaei was:
(a) AUG (b) GUG
(c) UAA (d) UUU

79. Which of the following becomes fatal in homozygous condition?
(a) Duplicate gene (b) Sex-linked gene
(c) Lethal gene (d) Epistatic gene

80. Maximum harm to a tree is done on removal of:
(a) All leaves (b) Bark
(c) Half flowers (d) Half branches

81. Maximum chloroplasts in leaves are in:
(a) Guard cells (b) Spongy parenchyma
(c) Palisade parenchyma (d) Epidermis

82. Water potential of root hair cells is mostly:
(a) 2 to 4 atmosphere (b) –4 to –6 atmosphere
(c) –1 to –2 atmosphere (d) 8 to 10 atmosphere

83. The phenomenon in which the leaves droop down at noon and regain turgidity in evening is called:
(a) Incipient wilting (b) Temporary wilting
(c) Permanent wilting (d) Wilting coefficient

84. Dumbbell shaped guard cells are characteristic of:
(a) All dicots (b) All monocots
(c) Grasses or cereals (d) Gymnosperms

85. Passive water absorption accounts for what percentage of total water absorbed by plant?
(a) 1–2% (b) 50–60%
(c) 80–90% (d) 96–100%

86. Sulphur containing amino acid is:
(a) Lysine (b) Histidine
(c) Methionine (d) Asparagine

87. Most of the sugars present in plants are of:
(a) L-form (b) D-form
(c) Both (a) and (b) (d) None of these

88. Essential component of electron transport chain is:
(a) Zn (b) Fe
(c) Cu (d) B

89. Empirical formula of carotene is:
(a) $C_{40}H_{56}$ (b) $C_{40}H_{56}O_2$
(c) $C_{20}H_{39}$ (d) None of these

90. Wavelength of light most effective or suitable for photosynthesis is:
(a) 400-500 nm (b) 700-750 nm
(c) 660-700 nm (d) 520-560 nm

91. Dimensions of chlorophyll molecule are:
(a) Head 15 Å × 15 Å and tail 25 Å
(b) Head 15 Å × 15 Å and tail 20 Å
(c) Head 20 Å × 20 Å and tail 15 Å
(d) Head 25 Å × 25 Å and tail 20 Å

92. Respiratory substrate of photorespiration is:
(a) Glycollic acid (b) Glyoxylic acid
(c) Glucose (d) Glycine

93. Pollen grains in dicots are generally:
    (a) Acolpate (b) Monocolpate
    (c) Bicolpate (d) Tricolpate
94. Endosperm of which plant is used in formation of billiard balls?
    (a) *Phoenix* (b) *Areca*
    (c) *Cocos* (d) *Phytephas*
95. Seeds of which plant are commonly called 'Black pearls'?
    (a) *Argemone mexicana* (b) *Elettaria cardamomum*
    (c) *Piper nigrum* (d) *Coffea arabica*
96. Which of the following protein amino acid has a single codon?
    (a) Tryptophan (b) Lysine
    (c) Valine (d) Phenyl alanine
97. Histones present in 'Nu bodies' are :
    (a) H_1, H_2A, H_2B, H_3 (b) H_1, H_2, H_3, H_4
    (c) H_2A, H_2B, H_3, H_4 (d) H_1, H_2A, H_2B, H_4
98. Euphotic zone in a deep water body is upto depth of:
    (a) 20 metre (b) 50 metre
    (c) 100 metre (d) 200 metre
99. Term cell has been derived from:
    (a) Greek word (b) Latin word
    (c) A new word (d) Roman word
100. Fungicide bordeaux mixture is chemically having:
    (a) Copper sulphate, Calcium hydroxide and ethanol
    (b) Copper sulphate, Calcium hydroxide and water
    (c) Zinc sulphate, Calcium hydroxide and water
    (d) None of the above

ANSWERS

1—b	2—c	3—b	4—d	5—d	6—a	7—c	8—d	9—a	10—c	11—b	12—b
13—a	14—c	15—c	16—c	17—c	18—c	19—c	20—d	21—a	22—c	23—d	24—d
25—b	26—b	27—a	28—d	29—c	30—a	31—b	32—d	33—c	34—d	35—a	36—c
37—c	38—d	39—b	40—b	41—c	42—d	43—c	44—b	45—d	46—c	47—c	48—d
49—b	50—c	51—b	52—d	53—d	54—d	55—b	56—a	57—c	58—c	59—a	60—a
61—c	62—b	63—d	64—a	65—a	66—c	67—b	68—c	69—b	70—d	71—a	72—b
73—a	74—c	75—c	76—d	77—c	78—d	79—c	80—b	81—c	82—b	83—b	84—c
85—d	86—c	87—b	88—b	89—a	90—c	91—b	92—a	93—d	94—d	95—c	96—a
97—c	98—b	99—b	100—b								

IMPORTANT DISCOVERIES OF SOME SCIENTISTS

S. No.	Year	Scientist Name	Discovery
1.	460–370 B.C.	Hippocrates	Father of medicine. He used plants in preparing medicines.
2.	384–322 B.C.	Aristotle	Father of Biology. He started the study of morphology.
3.	370–283 B.C.	Theophrastus	Father of Botany. He gave the description of 480 types of plants in "Historia Plantarum".
4.	1590	Z. Janssen and H. Janssen	Made first operational compound microscope.
5.	1665	Robert Hooke	Observed small compartments in a thin slice of cork and termed them cells.
6.	1674	A. van Leeuwenhoek	Discovered bacteria.
7.	1675	Malpighi	Made different, detailed studies in plant anatomy.
8.	1682	N. Grew	Father of plant anatomy. First of all described reproductive parts in plant.
9.	1694	R. J. Camerarius	Discovered sexuality in plants and gave the importance of pollination.
10.	1717	Thomas Fairchild	First plant hybrid was developed by him.
11.	1727	Stephen Hales	Father of plant physiology.
12.	1753	Carolus Linnaeus	Father of plant taxonomy. He gave '**Binomial system of nomenclature**' and wrote two books, *i.e.*, **Species Plantarum** and **Genera Plantarum**.
13.	1759	K. F. Wolff	Father of embryology.
14.	1781	Fontana	Observed nucleoli.
15.	1790	Goethe	Gave theory of metamorphosis of plant organs.
16.	1802	Lamarck, Treviranus	Term "Biology" was coined by them.
17.	1809	Jean Baptiste de Lamarck	Proposed the theory of Inheritance of acquired characters—Use and disuse of organs.
18.	1813	A.P. de Candolle	Term 'taxonomy' was coined by him.
19.	1817	Pelletier Caventou	'Chlorophyll' term was given by him.
20.	1823	Amici	Pollen tube was observed by him.
21.	1824	H. J. Dutrochet	Gave the concept that "**All tissues are a group of cells**".
22.	1828	Ehrenberg	Term **bacterium** was coined by him.
23.	1828	Robert Brown	Explained the movement of particles, *i.e.*, **Brownian movements.**
24.	1828	Brongniart	He classified plants into **Phanerogams** and **Cryptogams.**
25.	1831	Robert Brown	Discovered nucleus.
26.	1835	Felix Dujardin	Gave the term sarcode to living substance of cell.
27.	1835	Hugo Von Mohl	Described cell division and explained the importance of cell division.
28.	1835	M. J. Schleiden	Described nucleolus.
29.	1837	J. E. Purkinje	Coined the term "**protoplasm**".
30.	1838	M. Berzelius	Coined the term "**protein.**"
31.	1839	M. J. Schleiden and T. Schwann	Proposed **Cell theory.**
32.	1842	Mayer	Described the conversion of light energy into chemical energy during photosynthesis.
33.	1846	K. Nagelli	Proposed that plant cells arise from pre-existing cells.
34.	1849	W. Hofmeister	Observed fertilization and described nuclear division in *Tradescantia.*
35.	1850	Kollicker	Discovered **mitochondrion.**
36.	1851	W. Hofmeister	Explained alternation of generations.

37.	1858	R. Virchow	Discovered that new cells arise from pre-existing cells.
38.	1859	Charles Darwin	Introduced the theory of **Natural selection** and published the book **"Origin of species".**
39.	1861	De Bary and Max Schultze	Proposed **"Protoplasmic theory".**
40.	1862	George Bentham and J. D. Hooker	Wrote the book **"Genera Plantarum"** and introduced natural system of classification.
41.	1862	Kollicker	Coined the term **"cytoplasm".**
42.	1864	Louis Pasteur	Introduced "Germ theory of disease".
43.	1864	Schultze	Explained protoplasmic bridges.
44.	1864	Hanstein	He observed Sieve plates.
45.	1865	E. Haeckel	Term "plastid" was coined by him.
46.	1866	Gregor J. Mendel	"Father of genetics".
47.	1868	J. Huxley	Stated that "Protoplasm is the physical basis of life".
48.	1869	F. Miescher	First of all isolated **nuclein (DNA)** from pus cells.
49.	1870	W. His	Microtome was invented by him for cutting sections.
50.	1871	F. Miescher	Separated **nucleoprotein and nucleus.**
51.	1873	H. Fol	Defined astral rays.
52.	1878	Joseph Lister	Developed pure culture of bacteria.
53.	1878	W. Kuhne	Term enzyme was introduced by him.
54.	1879	W. Flemming	Coined the term **chromatin.**
55.	1880	E. Strasburger	Coined the term **nucleoplasm** and **cytoplasm** and described cell division in plants.
56.	1881	E. G. Balbiani	Discovered salivary gland chromosomes.
57.	1881	Focke	Proposed the term **xenia.**
58.	1882	W. Flemming	Coined the term **mitosis.**
59.	1883	W. Roux	Described that chromosomes have the units of heredity.
60.	1883	Schimper	Coined the term **chloroplast.**
61.	1883	Van Beneden	Proposed that gametes consist of half the number of chromosomes as compared to that of body cell.
62.	1884	Godlewski	Described the cause of upward movement of water.
63.	1884	E. Strasburger	Fertilization in angiosperms was described by him.
64.	1886	Van Tieghem	Gave stelar theory
65.	1887	A. Engler and A. E. Prantl	Phylogenetic system of classification was given by them.
66.	1888	W. Waldeyer	Introduced the term **chromosome.**
67.	1888	T. Boveri	Discovered centriole.
68.	1890	R. Altman	Discovered mitochondrion but named it **bioplast.**
69.	1892	Ivanowski	Proved the existence of viruses.
70.	1892	Weismann	Proposed theory of 'continuity of germplasm'.
71.	1894	E. Strasburger	Demonstrated occurrence of reduction division in plants.
72.	1894	Dixon and Jolly	Explained the cause of ascent of sap (Transpiration pull theory).
73.	1898	C. Benda	Coined the term **mitochondrion** instead of bioplast.
74.	1898	S. G. Nawaschin	She discovered **double fertilization** in angiosperms.
75.	1898	E. Buchner	Gave the name zymase for enzymes obtained from yeast cells.

76.	1899	R. Altman	Term nucleic acid was given by him to nuclein of Meischer.
77.	1900	E. Von Tschermak, Hugo de Vries and Carl Correns	Mendel's work was rediscovered by them independently.
78.	1901	E. Strasburger	Term plasmodesmata was given by him.
79.	1902	C.E. McClung	Sex chromosomes in grasshopper were observed by him.
80.	1902	W.S. Sutton	'Chromosome theory of heredity' was given by him.
81.	1905	Robert Koch (Nobel Prize)	Bacteria were cultured by him first of all (Study of tuberculosis).
82.	1905	W. Bateson	Term 'Genetics' was given by him.
83.	1905	J. B. Farmer and Moore	Coined the term 'meiosis'.
84.	1907	Harrison	Introduced the technique for growing tissues in culture medium.
85.	1907	Rosenberg	Explained apospory.
86.	1908	Winkler	Described apomixis.
87.	1909	W. L. Johannsen	Gave the term gene.
88.	1910	A. Kossel (Nobel Prize)	Explained the chemistry of nucleus.
89.	1911	P. Rous	Rous sarcoma virus was explained by him.
90.	1915	Richard Wilstatter	Chlorophyll was studied by him.
91.	1918	A. Stoll	Explained the structure and chemistry of chlorophyll.
92.	1920	W. Garner and Allard	Photoperiodism was discovered by them.
93.	1924	R. Feulgen	Developed test for DNA which is called as Feulgen reaction.
94.	1924	J. C. Bose	Showed that pulsatory activity of cortical cells results in ascent of sap.
95.	1926	T. Svedberg	Discovered ultracentrifuge.
96.	1926	J. Hutchinson	Gave the **'Phylogenetic system of classification'** of **angiosperms.**
97.	1927	H. J. Muller	Mutations were produced through X-rays.
98.	1928	Griffith	Performed transformation experiments with *Pneumococcus.*
99.	1929	Alexander Fleming	Penicillin was discovered.
100.	1930	Munch	'Mass flow hypothesis' was given by him.
101.	1931	Otto H. Warburg (Nobel Prize)	Showed action of respiratory enzymes.
102.	1932	M. Knoll and E. Ruska	Electron microscope was invented.
103.	1933	T. H. Morgan (Nobel Prize)	Described the role of chromosomes in transmission of heredity.
104.	1934	F. Kogl, H. Smith and Exleben	First of all isolated ~~IAA from human urine.~~
105.	1935	Jernike	Proposed principles of phase contrast microscopy.
106.	1935	K. V. Thimann	Demonstrated IAA in *Rhizopus.*
107.	1935	A. G. Tansley	Coined the term ecosystem.
108.	1936	M. C. Chailakhyan	Demonstrated flowering hormone, *i.e.*, florigen.
109.	1936	F. Gustaffson	Parthenocarpic fruit was produced by applying IAA.
110.	1937	H. Krebs (Nobel Prize 1953)	Citric acid cycle (Krebs' cycle) was discovered.
111.	1937	Yabuta, Hayashi and Sumuki	Gibberellin was crystallized.
112.	1940	R. Hill	Discovered light reaction of photosynthesis.
113.	1942	Oswald Tippo	Phylogenetic system of classification of plants was given.
114.	1944	Lederberg and Tatum	Conjugation in bacteria was discovered.
115.	1944	O.T. Avery, C.M. McLeod and M. McCarthy	Explained the role of DNA in heredity transmission in bacteria (Transformation).

116.	1945	K.R. Porter	Endoplasmic reticulum was discovered.
117.	1945	S. A. Waksman	Discovery of Streptomycin.
118.	1946	H.J. Muller (Nobel Prize)	Induced mutation by X-rays.
119.	1946	J. B. Sumner	First enzyme (Urease) was isolated.
120.	1952	Zinder and Lederberg	Transduction was discovered.
121.	1953	F.A. Lipman	Coenzyme-A was discovered.
122.	1954	D. I. Arnon	Observed photophosphorylation.
123.	1955	Palade	Discovered ribosomes in animal cells.
124.	1955	C. de Duve	Coined the term lysosome.
125.	1955	C.O. Miller and Skoog	Discovered kinetin.
126.	1955	A.H. T. Theorell	Described nature of oxidising enzymes.
127.	1957	H. F. Conrat	Showed that RNA is genetic material of tobacco mosaic virus.
128.	1958	G.W. Beadle, E.L. Tatum and K. Lederberg (Nobel Prize).	One gene one enzyme theory.
129.	1959	S. Ochoa and A. Kornberg (Nobel Prize)	*In-vitro* synthesis of polynucleotides of RNA and DNA.
130.	1959	F. Sanger (Nobel Prize)	Structure of insulin.
131.	1959	Robertson	Explained the concept of unit membrane.
132.	1961	Beevers	Glyoxysomes were discovered.
133.	1961	Nirenberg and Matthaei	Broke genetic code.
134.	1961	Malvin Calvin (Nobel Prize)	Observed path of carbon in photosynthesis.
135.	1962	Menke	Observed thylakoids in chloroplasts.
136.	1963	Chance and Parsons; Smith and Fernadez Moran	Elementary particles in mitochondria were discovered.
137.	1963	Nass and Nass	DNA was discovered in mitochondrion.
138.	1964	Park and Biggins	Quantasomes were discovered in chloroplasts.
139.	1965	F. Jacob and J. Monod (Nobel Prize)	Gave operon model of gene control.
140.	1966	P. Rous and C. Huggins (Nobel Prize)	Worked on cancer.
141.	1967	A. L. Takhtajan	Phylogenetic system of classification of angiosperms was given.
142.	1967	M. D. Hatch and C. R. Slack	Gave Hatch and Slack's pathway.
143.	1968	R. Holley, H. G. Khorana and M.W. Nirenberg (Nobel Prize)	Determined base sequence of t-RNA and studied genetic code.
144.	1969	Whittaker	Gave 5-kingdom classification of organisms.
145.	1969	H. G. Khorana	Gene synthesis for t-RNA.
146.	1969	Tolbert	Peroxisomes were discovered.
147.	1969	M. Delbruck, A. D. Hershey and S. E. Luria	Studied reproduction in viruses.
148.	1970	H. Harris	Gave the technique of DNA–RNA hybridization.
149.	1972	Singer and Nicolson	Fluid mosaic model of plasma membrane was given.
150.	1974	C. de Duve	Lysosomes were discovered.
151.	1974	G. E. Palade	Discovered ribosomes.
152.	1975	H. Temin and D. Baltimore (Nobel Prize)	Reverse transcription was discovered in sarcoma virus.
153.	1975	R. Dulbecco	Observed viruses as the cause of cancer.

154.	1978	W. Arber and D. Nathans (Nobel Prize)	Application of restriction enzymes.
155.	1980	F. Sanger (Nobel Prize)	Determination of base sequence of gene.
156.	1980	Paul Berg (Nobel Prize)	Explained gene splicing.
157.	1983	Barbara Mc Clintock (Nobel Prize)	Discovery of jumping genes or mobile genetic elements.
158.	1989	M. Bishop and H. Varmus (Nobel Prize)	Discovery of oncogenes.
159.	1991	Nehar and Sakmann (Nobel Prize)	Role of single ion channels in the cell.
160.	1992	Fischer and E. Krebs (Nobel Prize)	Reverse phosphorylation.
161.	1993	Roberts and Sharp (Nobel Prize)	Discovered split genes.
162.	1995	Lewis, Weischaus and Nuesslein Volhard (Nobel Prize)	Experiments were performed on *Drosophila* to control early embryonic development through genetic mechanism.
163.	1996	Peter C. Doherty and Rolf M. Zinkernagel (Nobel Prize)	Discovered the way by which the body detects virus infected cells.
164.	1997	Prusiner *et. al.* (Nobel Prize)	Discovered Prions which are responsible for scrapie disease in sheep.
165.	1998	Robert Furchgott, Ferid Murad, Louis Ignarro (Nobel Prize)	Discovered Viagra as an anti-impotence drug. Also discovered role of nitric oxide as an signalling molecule in cardiovascular system.
166.	1999	Gunter Blobel (Nobel Prize)	Worked on Protein signalling, which help in understanding different human diseases.
167.	2000	Arvid Carlson, Paul Greengurd and Eric Candle (Nobel Prize)	Worked on flow of signals in nervous system, which will help in developing medicines for dangerous diseases like Parkinson's disease and Schizophrenia.
168.	2001	Leland Hartwell, Paul Nurse and Timothy Hunt (Nobel Prize)	Worked on mechanism of control of cell cycle which is significant in biomedical research for cancer treatment.
169.	2002	Sydney-Brenner, John E. Sulston and H. Robert Horvitz (Nobel Prize)	Worked on genetic regulation of organ development and programmed cell death.

treatment
Cauli

oil
deposition

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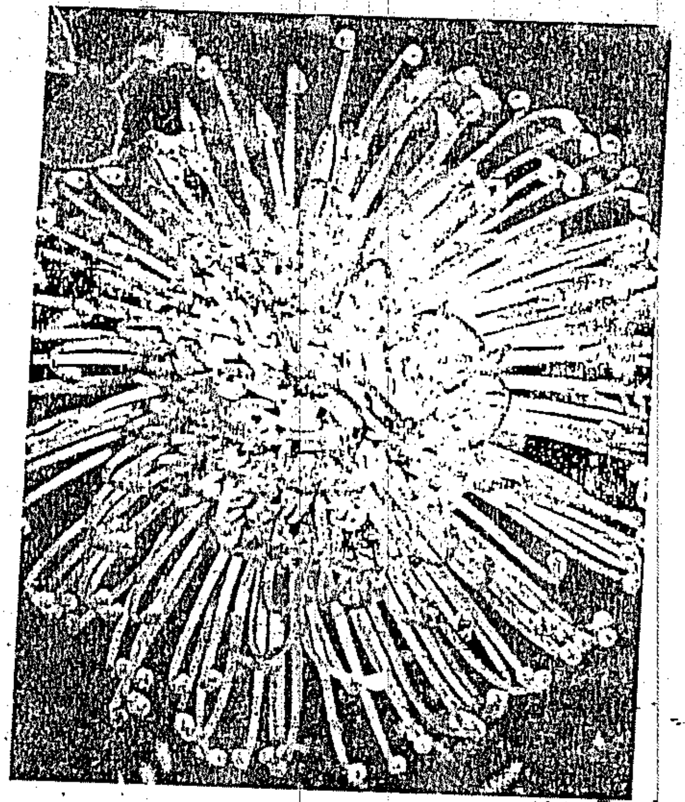

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